The Phase III Expansion of the White Street Sanitary Landfill

Greensboro, North Carolina

Construction Permit Application

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Originally Submitted Specifications

TABLE OF CONTENTS

SECTION 02220

EARTHWORK

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section Includes:
   1. Earthwork.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Condition of the Contract.
   2. Division 1 - General Requirements.
   3. Section 02276 Soil Liner System.
   4. Accompanying CQA Plan.

C. Definitions:
   1. Borrow: shall consist of approved material required for the construction of embankments/fills or for other portions of the work and shall be obtained from on-site areas designated on the plans unless directed otherwise by the Project Manager.
   2. Embankment and Fill: shall include construction of all site earthwork including roadways, landfill area, perimeter berm embankments, including preparation of the areas upon which materials are to be placed. All embankment and fill materials may be either (off-site) Select Borrow or (on-site) Borrow unless otherwise noted on drawings or specified by the Project Manager.
   3. Unsuitable Material: is any in-place or excavated material which contains undesirable materials, or is in a state which is not appropriate; in the opinion of the CQA Consultant, for the intended use or support of planned structures, embankment, or excavation. This may include but not be limited to organic material, soft, or materials not meeting required specifications, etc.

1.02 QUALITY ASSURANCE

A. Perform all work in accordance with requirements of local and state codes, with requirements of OSHA, and in accord with federal requirements.

B. Refer to the following standard references or specifications as applicable to this Section of Technical Specifications:
   1. North Carolina State Building Code, Latest Edition.
   2. North Carolina Erosion and Sediment Control Planning and Design Manual, Latest Edition.
   3. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.
   4. American Society for Testing Materials (ASTM).

a. D698, Tests for the Moisture Density Relations of Soils and Soil Aggregate Mixtures Using a 5.5 LB Rammer and a 12 IN Drop.
b. D1557, Tests for Moisture Density Relations of Soils and Soil Aggregate Mixtures Using a 10 LB Rammer and an 18 IN Drop.
c. D2487, Classification of Soils for Engineering Purposes.

C. Refer to "Construction Quality Assurance Plan" prepared by HDR Engineering for additional CQC/CQA procedures related to earthwork.

D. Hire an independent soils laboratory to conduct in-place moisture-density tests for backfilling to assure that all work complies with this Specification.

1.03 SUBMITTALS

A. See Section 01300.

B. Submit to CQA Consultant, for approval, source, test data as applicable, and samples of all off-site materials, a minimum of 14 days prior to intended use.

C. Submittals required by the Contractor or his subcontractors regarding earthwork CQC include the following:
1. All required CQC reports.
2. All required CQC laboratory data.
3. Soils inspection and testing results.

D. Additional information as outlined in Section 02276: Soil Liner System, and the accompanying CQA Plan.

1.04 SOILS/GEOTECHNICAL

A. The Owner will provide for the services of a CQA Consultant on-site to selectively test materials and monitor compliance with the requirements of these specifications. <u>This will be in addition to Construction Quality Control (CQC) provided and paid for by the Contractor performed by the CQC Agency in accordance with these specifications and the CQA Plan.</u>

B. The Contractor will afford these representatives access to the job site for the performance of their duties as described in the Contract Documents.

C. General Duties and Responsibilities of the Contractor CQC Agency:
1. Conduct Borrow Source Characterization Study (BSCS) in accordance with these specifications, Section 02276: Soil Liner System, and the CQA Plan.
2. Perform stockpile and in-place testing of all soil materials used in the work in conformance with these specifications and the CQA Plan.
3. Inspect subgrades and excavations and evaluate suitability of

materials encountered. Determine extent of any overexcavation required to remove unsuitable materials under roadways, structures, or other areas of construction.

4. Document placement of fill materials and perform testing to confirm compliance with these specifications.
5. Evaluate the suitability of existing on-site materials for use in construction of embankments and fills.
6. Measure quantity of unsuitable materials for payment on a unit price basis under contract provisions for authorized overexcavation and backfill.

D. General Duties and Responsibilities of Owner's CQA Consultant:
1. Approve materials proposed for incorporation into the work.
2. Review subgrades and excavations and approve suitability of materials encountered. Approve extent of any overexcavation required to remove unsuitable materials under roadways, structures, or other areas of construction.
3. Observe placement of fill materials and testing by CQC Agency for compliance with these specifications.
4. Review/approve the suitability of existing on-site materials for use in construction of embankments and fills.
5. Review construction operations and monitor for compliance with Contract Documents.
6. Review/approve CQC agency quantity of unsuitable materials for payment on a unit price basis under contract provisions for authorized overexcavation and backfill.

E. Available Subsurface Information: Where provided, data on subsurface soil conditions are not intended as representations or warranties of the continuity of such conditions between borings or indicated sampling locations. It shall be expressly understood that neither the Owner nor the Engineer will be responsible for any interpretation or conclusion drawn therefrom by the Contractor. Data is made available for the convenience of the Contractor.

F. Additional or supplementary soil borings or other exploratory operations may be made by the Contractor at no additional cost to the Owner. The Contractor shall provide the Owner with a copy of any data obtained/developed during such work. Such additional work shall be performed in a timely manner in accordance with and not impacting or changing the project schedule set forth in the Contract Documents.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Fill and Backfill: Selected material approved by Soils Engineer from site excavation.

B. The Contractor shall conduct his own quantity and quality investigations and testing to determine availability of (on-site) borrow

materials, as allowed by the Owner.

PART 3 - EXECUTION

3.01 PROTECTION

A. Protect existing surface and subsurface features on-site and adjacent to site as follows:
   1. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing items indicated to remain in place.
   2. Protect and maintain bench marks, monuments or other established reference points and property corners. If disturbed or destroyed, replace at own expense to full satisfaction of Owner and controlling agency.
   3. Verify location of utilities. Omission or inclusion of utility items does not constitute non-existence or definite location. Secure and examine local utility records for location data.
      a. Take necessary precautions to protect existing utilities from damage due to any construction activity.
      b. Repair damages to utility items at own expense.
      c. In case of damage, notify Engineer at once so required protective measures may be taken.
   4. Maintain free of damage, existing sidewalks, structures, and pavement, not indicated to be removed. Any item known or unknown or not properly located that is inadvertently damaged shall be repaired to original condition. All repairs to be made and paid for by Contractor.
   5. Provide full access to public and private premises, fire hydrants, street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.
   6. Maintain stockpiles and excavations in such a manner to prevent inconvenience or damage to structures on-site or on adjoining property.
   7. Avoid surcharge or excavation procedures which can result in heaving, caving, or slides.
   8. Conduct operation with minimum interference to daily landfill operations.

B. Construction erosion and sedimentation controls prior to beginning earthwork.

C. Dispose of waste materials, legally. Burning, as a means of waste disposal, is not permitted.

3.02 SITE EXCAVATION AND GRADING

A. The work includes all operations in connection with excavation, borrow, construction of fills and embankments, rough grading, and disposal of excess materials in connection with the preparation of the site(s) for construction of the proposed facilities.

B. Excavation and Grading: Perform as required by the Contract Drawings.

1. Contract Drawings may indicate both existing grade and finished grade required for construction of Project. Stake all units, structures, piping, roads, parking areas and walks and establish their elevations. Perform other layout work required. Replace property corner markers to original location if disturbed or destroyed.
2. Preparation of ground surface for embankments or fills: Before fill is started, scarify to a minimum depth of 6 IN in all proposed embankment and fill areas. Where ground surface is steeper than one vertical to four horizontal, plow surface in a manner to bench and break up surface so that fill material will bind with existing surface.
3. Protection of finish grade: During construction, shape and drain embankment and excavations. Maintain ditches and drains to provide drainage at all times. Protect graded areas against action of elements prior to acceptance of work. Reestablish grade where settlement or erosion occurs.

C. Borrow: Provide necessary amount of approved fill compacted to density equal to that indicated in this Specification. Include cost of all borrow material in original proposal. Fill material to be approved by Soils Engineer prior to placement.

D. Construct embankments and fills as required by the Contract Drawings:

1. Construct embankments and fills at locations and to lines of grade indicated. Completed fill shall correspond to shape of typical cross section or contour indicated regardless of method used to show shape, size, and extent of line and grade of completed work.
2. Provide approved fill material which is free from roots, organic matter, trash, frozen material, and stones having maximum dimension greater than 6 IN. Ensure that stones larger than 4 IN are not placed in upper 6 IN of fill or embankment. Do not place material in layers greater than 8 IN loose thickness. Place layers horizontally and compact each layer prior to placing additional fill.
3. Compact by sheepsfoot, pneumatic rollers, vibrators, or by other equipment as required to obtain specified density. Refer to Table A for testing frequencies. Control moisture for each layer necessary to meet requirements of compaction.

E. Upon reaching subgrade elevations shown, proofroll subgrade soils and obtain the CQC Agency's and CQA Consultant's approval. If unsuitable materials are encountered at the subgrade elevation, perform additional excavation as directed by the CQC Agency and reviewed by the CQA Consultant to remove unsuitable materials. Excavation of 1 CY or greater should be preapproved by the CQA Consultant.

TABLE A

Minimum Testing Frequency for Soil Materials
(Refer to CQA/CQC Plan for Methods)

Components	Required Test	Minimum Sample Frequency/Location	Acceptance or Rejection Criteria
Backfill of Unsuitable Areas (Granular)	1. Particle Size	1. 1 Per Source	1. NCDOT No. 78M
	2. In-place Density	2. 1/Area Judged Unsuitable	2. As per Section 02221, paragraph 3.05C.
Structural/Controlled Fill	1. Classification	1. 1 Per Source	1. Meet Select Borrow/ Borrow as Per 2.01 A.
	2. Standard Proctor Density or Relative Density	2. 2 Per Soil Type/Source	2. None.
	3. In-Place Density A. Cohesive Soil	3. 1 Per 10,000 S.F. Per Lift	3.A. 95% maximum density (Standard Proctor; 2%± Opt. Moisture except under Foundations/ Structures 98% Standard Proctor.
	B. Granular Soil		3.B. 75% Relative Density

F. Proofrolling shall be conducted with a pneumatic tired vehicle of at least 20 tons GVW, approved by the CQA Consultant. An alternate approved by the CQA Consultant may be used in constricted areas.

G. Where subgrade materials are determined to be unsuitable, such materials shall be removed to the lengths, widths and depths directed by the CQC Agency and approved by the CQA Consultant and backfilled with suitable material unless further excavation or earthwork is required. No additional payment will be made for such excavation and backfill 2 feet or less than the finished subgrade. Unsuitable material excavation greater than 2 feet beneath the finished subgrade shall be made on a unit price basis for excavation and backfill, only as approved by the CQA Consultant and Project Manager. Unit price for overexcavation and backfill greater than 2 feet in depth shall include disposal of unsuitable materials.

H. The subgrade of areas to receive fill shall be smooth and free of all vegetation, sticks, roots, rocks and debris.

I. Dewatering: Provide and maintain dewatering of all surface water and/or groundwater as required for excavation. Where groundwater is or is expected to be encountered during excavation, install a dewatering system to prevent softening and disturbance of subgrade below foundations and fill material, to allow foundations, fill material, and structures/backfill to be placed in the dry, and maintain a stable excavation. Groundwater shall be maintained at least 4 feet below the bottom of any excavation. Soils and hydrogeologic information may be reviewed before beginning excavation to determine where groundwater is likely to be encountered during excavation. Employ a dewatering specialist for selecting/designing, monitoring and operating the dewatering system as needed. Keep dewatering system in operation until dead load of structure exceeds possible buoyant uplift force on structure or fill material. Dispose of groundwater to an area which will not interfere with construction operations or damage existing construction as approved by the Owner. Install groundwater monitoring points as necessary. Shut off dewatering system at such a rate so as to prevent a quick upsurge of water that might weaken the subgrade. Installation, start-up, monitoring maintenance, and shut-off of the dewatering system shall be at no additional cost to the Owner.

J. Do not place fill when the subgrade to receive fill is frozen, wet loose or soft.

K. Moisture control:
   1. Moisture content of materials prior to, and during compaction, shall be uniform throughout each layer of material.
   2. Granular materials shall be thoroughly wetted during or immediately prior to compaction.
   3. Supplementary water shall be added as required to materials by sprinkling and mixing uniformly throughout layer.
   4. Materials too wet for placing shall be temporarily spread or

aerated until moisture content is acceptable. If these materials cannot be processed in time to use, the Contractor shall find alternatives acceptable to the CQC Agency and the CQA Consultant.

3.03 ROCK EXCAVATION

A. All rock excavation shall be under one classification. This classification shall include solid ledge rock in its natural location that requires systematic quarrying, drilling and/or splitting for its removal and also boulders that exceed 1/2 CY in volume. Rock is defined as natural material that cannot be ripped with a D-9 bulldozer or similar equipment.

B. When rock is encountered immediately notify Engineer. Strip free of earth. Employ an independent surveyor to determine rock quantities before removal operation begins. In computing the volumetric content of rock excavation for payment, the pay lines shall be taken as follows:
   1. For structures: 3 FT outside the exterior limits of foundations and from rock surface to 6 IN below bottom of foundations.
   2. For piping and utilities: A width 18 IN wider than the outside diameter of the pipe or conduit and from rock surface to 6 IN below bottom exterior surface of the pipe or conduit.
   3. For paving: 2 FT outside the exterior limits of paving and from rock surface to 6 IN below bottom of pavement subbase.
   4. For landfill unit: 5 FT below subgrade and from rock surface.

3.04 METHOD OF REMOVAL AND PAYMENT

A. Method of removal to be coordinated during construction.

B. Payment terms to be negotiated at time of identification of rock.

3.05 FINISH GRADING

A. Grade all areas disturbed by construction operations.

B. Grade to smooth, uniformly sloping surfaces to existing elevations or to finish elevations shown on drawings.

C. Grading shall be to a tolerance of 2 IN (plus/minus) unless otherwise noted elsewhere in these specifications or in the accompanying CQA/CQC Plan.

3.06 GRADING ADJACENT TO STRUCTURES

A. Evenly slope finished grade away from structures as shown on drawings to provide drainage.

3.07 FIELD QUALITY CONTROL

A. Moisture density relations, to be established by the Soils Engineer required for all materials to be compacted.

B. Extent of compaction testing will be as necessary to assure compliance with Specifications.

C. Give minimum of 24 HR advance notice to Soils Engineer when ready for compaction or subgrade testing and inspection.

D. Should any compaction density test or subgrade inspection fail to meet Specification requirements, perform corrective work as necessary.

E. Pay for all costs associated with corrective work and retesting resulting from failing compaction density tests.

3.08 COMPACTION DENSITY REQUIREMENTS

A. Obtain approval from Soils Engineer with regard to suitability of soils and acceptable subgrade prior to subsequent operations.

B. Provide dewatering system necessary to successfully complete compaction and construction requirements.

C. Remove frozen, loose, wet, or soft material and replace with approved material as directed by Soils Engineer.

D. Stabilize subgrade with well graded granular materials as directed by Soils Engineer.

E. Assure by testing, at a frequency of a minimum of 1 test per lift per 10,000 square feet, that compaction densities comply with the following requirements:

1. Sitework:

LOCATION	COMPACTION DENSITY
WITHIN CONSTRUCTION BASELINE AND UNDER PAVED AREAS	
Cohesive Soils	95 percent, ASTM D698
Cohesionless Soils	75 percent relative density per ASTM D4253 and D4254
OTHER AREAS:	
Cohesive Soils	95 percent, ASTM D698

Cohesionless Soils	75 percent relative density per ASTM D4253 and D4254

3.08 ACCEPTANCE OF WORK

A. Obtain approval of excavations and pre-fill subgrade from the CQA Consultant before starting any construction. Approval may consist of satisfactory proofroll observed by the CQC Agency and CQA Consultant.

3.09 SPECIAL REQUIREMENTS

A. Erosion Control: Conduct work to minimize erosion of site. Construct stilling areas to settle and detain eroded material. Remove eroded material washed off site. Clean streets daily of any spillage of dirt, rocks or debris from equipment entering or leaving site.

B. The Owner shall provide the Contractor with a current survey. Quantities for mass excavation are defined as the difference between the current survey provided and the base grades shown on Drawing C-2. The Contractor shall confirm the survey to their satisfaction and resolve any differences with the Engineer prior to commencing work.

END OF SECTION

SECTION 02221

TRENCHING, BACKFILLING AND COMPACTING

PART 1 - GENERAL

1.01 DESCRIPTION

A. General:
   1. Furnish all labor, materials, tools, equipment and services for excavation, trenching, backfilling and compacting for all utilities, culverts, pipes, manholes, etc. as indicated, in accord with provisions of Contract Documents.
   2. Completely coordinate with work of all other trades.

B. Work included in the project consists of, but is not limited to, methods of installation of the following:
   1. Surface drainage culverts and piping.
   2. Leachate gravity header piping outside lined areas.

C. Related Work Specified

   1. Section 02220: Earthwork.

   2. Section 02276: Soil Liner System.

   3. Section 02775: Geosynthetic Liner System.

1.02 QUALITY ASSURANCE

A. Referenced Standards.

   1. American Society for Testing and Materials (ASTM)

      C33 Concrete Aggregates
      D2049 Relative Density for Cohesionless Soils
      D2487 Classification of Soils for Engineering Purposes
      D698 The Moisture-Density Relations of Soils using a 5.5-pound Rammer and a 12 IN drop

B. Contractor shall perform all required horizontal and vertical layout work. Such work shall be performed by a qualified surveyor or engineer.

C. Refer to the accompanying CQA Plan.

1.03 SUBMITTALS

A. See Section 01340.

B. Submit test reports and fully document each with specific location or stationing information, date, and other pertinent information.

1.04 JOB CONDITIONS

A. Verify location and existence of utilities.

B. Take necessary precautions to protect existing utilities from damage due to any construction activity. Repair damages to utility items at own expense. Assess no cost to Owner, Engineer, or auxiliary party for any damages.

C. Avoid overloading or surcharging a sufficient distance back from edge of excavations to prevent slides or caving. Maintain and trim excavated materials in such a manner as to be as little inconvenience as possible to the public and adjoining property owners.

D. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction and at no cost to Owner and controlling agency.

1.05 CLASSIFIED EXCAVATION

A. Remove rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by Engineer and dispose of to a site approved by the Owner. All rock excavation shall be considered classified excavation. Separate or additional payment will be made for rock excavation. See Section 02220.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Backfill material: As approved by the CQA Consultant as borrow or select borrow material.
   1. Free of rock, cobbles, roots, sod or other organic matter, and frozen material.
   2. The material used for backfill may be obtained from excavations or borrow stockpiles within the project limits of construction entirely apart from the segment of trench being backfilled.

B. Subgrade stabilization materials:
   1. Provide subgrade stabilization material in areas directed by the CQA Consultant consisting of NCDOT No. 78M.

C. Granular bedding materials:
   1. Unless specified otherwise on the plans, provide granular trench bedding material consisting of well-graded crushed stone or crushed gravel meeting NCDOT Specifications, Size No. 78M requirements.
   2. Where granular backfill materials are indicated, place in full compliance with methods prescribed in these specifications.

3. Other granular material may be accepted by the Project Manager or CQA Consultant.

PART 3 - EXECUTION

3.01 GENERAL

A. Remove and dispose of unsuitable materials at an approved site.

B. Excavate trench, backfill and compact for all underground pipe lines, structures, bases and appurtenant items.

C. Provide dewatering as required for maintaining stable subgrade and for pipe installation.

3.02 EXCAVATION

A. Excavation for appurtenances:
1. Excavate for appurtenant structures to provide at least 12 IN (minimum) clear distance between outer surface and embankment and in full observation to Safety Rules.

B. Trench excavation:
1. Unless allowed otherwise by the CQA Consultant and Project Manager, excavate trenches by open cut method to depth shown on drawings and or necessary to accommodate work.
2. Open trench lengths shall be no more than the distance between two manholes, structures, units, or 500 linear FT, whichever is greater. Trenching limitations may be field adjusted as weather conditions dictate.
3. Do not open a greater length of trench than can be effectively utilized under existing conditions. Schedule work and order materials so that trenches are not left open for a longer period than is reasonably necessary. Any trench or portion of trench, which is opened and remains idle for seven calendar days, or longer, as determined by the Project Manager, may be directed to be immediately refilled, without completion of work, at no additional cost to Owner. Said trench may not be reopened until Project Manager is satisfied that work associated with trench will be prosecuted with dispatch.
4. Observe following trenching criteria:
a. Trench size. Excavate only sufficient width to accommodate free working space. In no case shall trench width at top of pipe or conduit exceed outside diameter of piping and/or conduit service by the following dimensions:

Overall Diameter of Utility Service	Excess Dimension
33 IN and less	18 IN
More than 33 IN	24 IN

b. Cut trench walls vertically from bottom of trench to 1 FT above top of pipe, conduit, or utility service.

c. Keep trenches free of water. Include cost of dewatering in firm base bid price.

d. Support, brace and/or sheet trenches as soil conditions dictate and in full observation of latest OSHA requirements. Do not remove support until backfilling has progressed to a stage that no damage to piping, utility service, or conduit will result due to removal. The support shall be designed by an Registered Profession Engineer experienced in this type of design. Construction site safety is the sole responsibility of the Contractor.

3.03 PREPARATION OF FOUNDATION FOR PIPE LAYING

A. If authorized overexcavation occurs, backfill and compact as per Section 3.05B.

B. Subgrade stabilization: Provide subgrade stabilization when directed by the CQA Consultant in accordance with these specifications and details when shown. Observe the following requirements when unstable trench bottom materials are encountered.
1. Notify Engineer when unstable materials are encountered and define by drawing station locations and limits.
2. Remove unstable trench bottom and replace with subgrade stabilization.
3. No additional compensation will be allowed for unstable conditions resulting from Contractor failure to protect the work.

3.04 BACKFILLING - GENERAL

A. Place backfill in lifts not exceeding 8 IN (loose thickness).

B. Observe specific pipe or conduit manufacturer's recommendations regarding methods of backfilling and compaction.

C. Exercise extreme care in backfilling operations to avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation or distortion. Repair damages, distortions or misalignments to full satisfaction of CQA Consultant.

D. Water flushing for consolidation is not permitted.

3.05 COMPACTION

MINIMUM COMPACTIONS

LOCATION	SOIL TYPE	DENSITY
All applicable areas	Cohesive soils	95 percent of max dry density by ASTM D698
	Cohesionless soils	75 percent of max relative density by ASTM D4253 and D4254

A. Relative density of predominantly granular bedding or backfill may be accepted by the CQC Agency (and approved by the CQA Consultant) based on visual inspection without relative density testing, as deemed appropriate by CQA Consultant.

3.06 FIELD QUALITY CONTROL

A. Testing:
   1. The Contractor's CQC Agency shall perform in-place moisture and density tests as required to ensure that trench bedding and backfill complies with specified requirements. Costs of "Passing" tests shall be paid by Owner. Where backfill compaction does not meet moisture density test requirements and after backfill has been removed as directed by the CQC Agency and situation corrected, additional tests shall be performed until compaction meets or exceeds requirements with cost borne solely by Contractor. Costs associated with "Failing" tests shall be paid by Contractor.
   2. Ensure Owner has at all times immediate access to the test results of all soils related work. Ensure excavations are in a safe condition for testing personnel.
   3. Demonstrate compaction by testing at a frequency of 1 test per lift per 1,000 linear feet.

B. Ensure full compliance to applicable requirements of OSHA.

C. Special attention is directed to Title 29 Labor, Part 1518 - "Safety and Health Regulations for Construction" and detailed requirements of Subpart P "Excavations, Trenching and Shoring."

END OF SECTION

SECTION 02485

SEEDING

PART 1 - GENERAL

1.01 DESCRIPTION

A. General:
   1. Furnish all labor, materials, tools, equipment and services for seeding in accordance with provisions of Contract Documents.
   2. Completely coordinate with work of all other trades.
   3. See Division 1 for General Requirements.

B. Related work specified elsewhere:
   1. Section 02260 - Topsoiling.
   2. Section 02220 - Earthwork.
   3. Section 02221 - Trenching, Backfilling, and Compacting.

C. Location of work: All disturbed areas, exclusive of lined landfill area.

1.02 QUALITY ASSURANCE

A. Fertilizer testing: Current methods of Association of Official Agricultural Chemists.
   1. Testing will be conducted at discretion of Engineer.

1.03 SUBMITTALS

A. See Section 01300.

B. Certificates for each grass seed mixture, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed. Certify that each container of seed delivered is fully labeled in accordance with Federal Seed Act and equals or exceeds specification requirements.

C. Copies of invoices for fertilizer, showing grade furnished and total quantity applied.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Establish a smooth, healthy, uniform, close strand of grass from specified seed.

B. Grass seed: Fresh, clean, new-crop seed.
   1. Species, proportions and minimum percentage of purity, germination, and maximum percentage of weed seed, as specified.

2. Provide following grass seed mixtures:

Botanical and Common Name	Pct. by Weight	Min. pct. Germ	Min. pct. Purity
Kentucky 31 Fescue	100	80	97.0

C. Mulch: Clean, seed-free, thressed straw of oats, wheat, barley, rye, beans, or other locally available mulch material.
1. Do not use mulch containing a quantity of matured noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.
2. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.

D. Fertilizer: Commercial fertilizer of 10-10-10 analysis, meeting applicable requirements of State and Federal law.
1. Do not use cyanamic compounds of hydrated lime.

E. Limestone: agricultural grade ground limestone containing not less than 85 percent of combined calcium and magnesium carbonates.
1. 50 percent passing 100 mesh sieve.
2. 90 percent passing 20 mesh sieve.

F. Asphalt binder: Emulsified asphalt per State Specifications.

G. Water: Potable, free of substances harmful to growth.

H. Erosion Control Matting: Provide "Hold-Grow" type erosion control nets or approved equal. Contractor shall provide erosion control matting as required on slopes and ditchlines to obtain suitable vegetative cover.

2.02 DELIVERY, STORAGE AND HANDLING

A. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

B. Deliver fertilizer in original containers labeled with content analysis.

PART 3 - EXECUTION

3.01 JOB CONDITIONS

A. Perform spring seeding between March 1 and May 1, and fall seeding between September 15 and November 15, or upon approval of the Engineer.

3.02 SOIL PREPARATION

A. Limit preparation to areas which will be planted soon after preparation.

B. Loosen surface to minimum depth of four (4) IN.

C. Remove stones over one (1) IN in any dimension, sticks, roots, rubbish and other extraneous matter.

D. Test soil pH using test kits approved by USDA NRCS. Use test results to determine rate of lime application needed to make soil circumneutral. Engineer will approve application rate prior to its application.

E. Spread lime uniformly over designated areas at rate determined by soil testing.

F. After application of lime, prior to applying fertilizer, loosen areas to be seeded with double disc or other suitable device if soil has become hard or compacted. Correct any surface irregularities in order to prevent pocket or low areas which will allow water to stand.

G. Test soil fertility according to USDA NRCS approved methods. Use test results to determine rate of fertilizer application. Engineer will approve fertilizer application rate prior to application.

H. Distribute fertilizer uniformly over areas to be seeded at a rate determined by soil testing.
   1. Use suitable distributor.
   2. Incorporate fertilizer into soil to depth of at least two (2) IN.
   3. Remove stones or other substances which will interfere with turf development or subsequent mowing.

I. Grade seeded areas to smooth, even surface with loose, uniformly fine texture.
   1. Roll and rake, remove ridges and fill depressions, as required to meet finish grades.
   2. Fine grade just prior to planting.

J. Restore seeded areas to specified condition if eroded or otherwise disturbed between fine grading and planting.

K. If fertilizer application rate is determined (by invoices submitted) to be less than that specified, apply additional fertilizer.

3.03 SEEDING

A. Temporary Seeding:
   1. Do not use seed which is wet, moldy, or otherwise damaged.
   2. Seed the appropriate species for the planting season as specified in 2.01 A.4.
   3. Employ satisfactory methods of sowing using mechanical power

driven drills or seeders, or mechanical hand seeders, or other approved equipment.

4. Evenly apply seed at the following rates:

Species	Rate (lb/acre)
Winter Rye	120

5. Small grains should be planted no more than 1 inch deep, and grasses no more than 1/2 inch deep.
6. Lightly rake seed into soil followed by light rolling or cultipacking.
7. Anchor straw by tacking with emulsified asphalt or netting or other methods approved by Engineer.
8. Inspect all seeded areas and make necessary repairs of re-seedings within planting season, if possible. If stand is over 60% damaged, re-establish planting area following recommendations specified for lime, fertilizer and seeding.
9. Clean-up: Remove any soil or similar material from paved areas within same working day. Upon completion of seeding, remove all excess soil, stones, and other debris from site or dispose as directed by Owner. Repair all damages to existing construction caused by lawn operations to the satisfaction of Architect and Owner at no additional cost to Owner.

B. Do not use seed which is wet, moldy, or otherwise damaged.

C. Use approved mechanical power driven drills or seeders, or mechanical hand seeders, or other approved equipment.

D. Distribute seed evenly over entire area at not less than 7LB/1000 SF, 50 percent sown in one direction, remainder at right angles to first sowing.

E. Stop work when work extends beyond most favorable planting season for species designated, or when satisfactory results cannot be obtained because of drought, high winds, excessive moisture, or other factors.

F. Resume work only when favorable condition develops.

G. Lightly rake seed into soil followed by light rolling or Cultipacking.

H. Immediately protect seeded areas against erosion by mulching or placing netting.
   1. Spread mulch in a continuous blanket using 1-1/2 TON/ACRE to depth of 4 or 5 straws.
   2. Immediately following spreading mulch, secure with evenly distributed emulsified asphalt at rate of 200 gal/acre.
   3. Protect all seeded slopes greater than 2:1 (horizontal to vertical) against erosion with approved erosion control netting or mats.

I. Immediately after planting, water to a depth of 2 inches.

3.04 MAINTENANCE

A. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

B. Replant bare areas using same materials specified.

C. Contractor shall supply sufficient water until grass is established.

END OF SECTION

SECTION 02240

OPERATIONAL COVER AND LEACHATE COLLECTION LAYER

PART 1 - GENERAL

1.01 DESCRIPTION

A. General:
   1. Furnish all labor, materials, tools, equipment and services for installation and placement of the operational cover and leachate collection layer, as indicated, in accordance with provisions of Contract Documents.
   2. Completely coordinate with work of all other trades.
   3. Although such work is not supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure, complete and compatible installation.
   4. See Division 1 for General Requirements.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02220: Earthwork.

B. Section 02276: Soil Liner System.

C. Section 02775: Geosynthetic Liner System.

D. Section 02900: Geotextiles.

E. Section 15064: Pipe: Plastic.

1.03 QUALITY STANDARDS

A. Referenced Standards
   1. American Society for Testing and Materials:
      a. D422 - Particle Size Analysis.
      b. D2434 - Permeability of Granular Soils.
      c. D4373 - Calcium Carbonate Content of Soils.
      d. D5084 - Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
   2. North Carolina Department of Transportation (NCDOT), Standard Specifications for Roads and Structures, 1990 or current edition.
   3. Refer to "Construction Quality Assurance Plan" prepared for Hanes Mill Landfill Lateral Expansion.

1.04 SUBMITTALS

A. See Section 01300: Submittals.

B. At least four weeks prior to construction of the leachate collection layer, submit a bulk sample of each material from each

source to the CQA Consultant for approval.

C. Submit all required laboratory test data as required by Subparts 2.01 and 3.02 for materials used in the construction.

1.05 JOB CONDITIONS

A. Take necessary precautions to protect synthetic landfill liner from damage due to any construction activity. Repair damages to liner at own expense. Assess no cost to Owner, Engineer, or auxiliary party for any damages to liner system or pipe resulting from placement of stone or activities of equipment operating on stone.

B. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.

1.06 TOLERANCES

A. Materials shall be placed to the lines and grades as shown on the Contract Drawings except that a 2-inch overbuild is allowed. Material placed beyond these limits shall be removed at Contractor's expense.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Material: The CQC Consultant shall submit source test data to the CQA Engineer from borrow stockpiles prior to delivery to the site.
1. Free of roots, sod or other organic matter, and frozen material. The material shall be of durable and of noncarbonaceous origin.
2. Materials must meet acceptance criteria presented in 3.02 of this Section.

PART 3 - EXECUTION

3.01 GENERAL

A. The leachate collection layer is placed directly over Geomembrane, collector pipes, and Geotextile cushion; thus, extreme caution shall be exercised by the Contractor to prevent damage to these materials.

B. Placement of these materials within the cell shall be conducted only when the CQA Consultant or his representative is present at the site and informed in advance of the intent to complete this work.

C. The Contractor shall exercise care in maintaining a true line and

grade an all piping during placement and spreading of the material.

D. Materials shall be placed over the Geomembrane only after areas have been released by the Geomembrane Installer and the CQA Consultant. The materials shall be placed as specified below.
   1. All materials shall be placed and spread with low ground pressure equipment (6 psi ground pressure or less) as approved by the Engineer to reduce potential damage to the Geomembrane. The Geomembrane surface shall be off limits to construction traffic. Excessive hard turning of tracked equipment on the stone must be avoided.
   2. At least 12 IN (12") of separation between the Geomembrane and equipment shall be maintained.
   3. Material shall not be placed over standing water or ice.
   4. Material shall not be compacted within the cell limits.

E. The leachate collection layer shall be spread in a manner that minimizes development of folds in the Geomembrane. Any portions of the Geomembrane that develop crimp shall be repaired by the Geomembrane Installer at no expense to the Owner.
   1. If during spreading, excessive wrinkles develop, the Contractor shall adjust placement and spreading methods, or cease until the Geomembrane cools and wrinkles decrease in size.
   2. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and spreading methods shall be cut and repaired by the Geomembrane Installer in a method approved by the CQA Consultant.

F. Any damage to the underlying Soil or Geomembrane Liners or Geotextiles or shall be repaired in accordance with the applicable section of these Specifications at Contractor expense.

G. Stockpiling of materials within the limits of the cell shall be subject to advanced approval by the CQA Consultant. Any hauling equipment (dump trucks, etc.) operating within the cell limits, including access ramps, shall have a minimum of 3-ft. of separation between the vehicle wheels and the Geomembrane.

H. Any areas where unauthorized or tracked equipment has operated over the leachate collection system shall be subject to investigation for potential Geomembrane damage. Such investigations may include removal of overlying materials in the affected areas and visual inspection of the Geomembrane. These activities shall be conducted under direction by the CQA Consultant at Contractor's expense.

I. Test areas to evaluate potential damage due to equipment operations may be required by the CQA Consultant to assess equipment to be used by the Contractor. The test area shall be outside the cell limits, use scrap materials not to be used in cell construction, and model construction conditions as closely as is practical. Test area parameters shall be determined by the CQA Consultant and Contractor in advance of construction of the leachate collection

system.

3.02 QUALITY CONTROL

A. The CQC Consultant shall perform testing of the materials.

B. Ensure CQA Consultant has at all times immediate access for the testing of all related work.

TABLE A

Minimum CQC Testing Frequency

Components	Required Test	Minimum Sample Frequency/ Location	Acceptance Criteria
Leachate Collection Stone Layer	1. Permeability (ADTM D2434)	1 per 2000 CY	$K \geq 1 \times 10^{-1}$ cm/sec
	2. Carbonate Content (ASTM D4373)	1 per source	<15% by weight
	3. Thickness	1 per acre	12" to 14"
Leachate Collection Stone Around Piping	1. Gradation (ADTM D422)	1 per 1500 CY	NCDOT No. 57 Stone
	2. Carbonate Content (ASTM D4373)	1 per source	<15% by weight
Operational Cover Soil	1. Permeability (ASTM D2434 or ASTM D5084)	1 per 2000 CY	$K \geq 2 \times 10^{-5}$ cm/sec
	2. Thickness	1 per acre	12" to 14"

END OF SECTION

SECTION 02276

SOIL LINER SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Contractor to furnish all labor, materials, tools, equipment, and services for soil liner components as indicated, in accordance with provisions of Contract Documents.
   2. Completely coordinate with work of all other trades.
   3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

B. Related Sections include but are not necessarily limited to:
   1. Section 02110 - Site Clearing.
   2. Section 02200 - Earthwork.
   3. Section 02775 - Geosynthetic Liner System.
   4. Construction Quality Assurance Plan.

1.02 QUALITY STANDARDS

A. Reference Standards:
   1. ASTM - American Society for Testing and Materials
      a. ASTM D-422 - Particle Size Analysis
      b. ASTM D-698 - Standard Proctor
      c. ASTM D-854 - Specific Gravity
      d. ASTM D-1140- Fines Content in Soils
      e. ASTM D-1556 - In-situ Density Measurement Using the Sand Cone
      f. ASTM D-1557 - Modified Proctor
      g. ASTM D-2166 - Unconfined Compressive Strength
      h. ASTM D-2216 - Moisture Content Using Over-Dry Method
      i. ASTM D-2487 - Soils Classification
      j. ASTM D-2573 - Field Vane Shear Test
      k. ASTM D-2922 - In-situ Density Using Nuclear Methods
      l. ASTM D-3017 - In-situ Moisture Content Using Nuclear Methods
      m. ASTM D-4318 - Atterberg Limits
      n. ASTM D-5084 - Flexible Wall permeameter
   2. USEPA - United States Environmental Protection Agency
      a. EPA/600/R-93/182 -"Quality Assurance and Quality Control for Waste Containment Facilities," September, 1993.
   3. Construction Quality Assurance Plan," prepared for Hanes Mill Landfill Expansion, dated September 1995.

1.03 SUBMITTALS

A. See Section 01300 - Submittals.

B. Refer to the CQA Plan.

1.04 JOB CONDITIONS

A. Verify conditions of subgrade prior to commencing work.

1.05 TOLERANCES

A. The soil liner system must exceed the following tolerances:
   1. The saturated hydraulic permeability of the soil liner must be equal to or less than 1.0 x 10-7 cm/sec, as determined by ASTM D5084.
   2. The thickness of the soil liner must be equal to or greater than 24 inches. An overbuild of 2-inches is allowed for the soil liner.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Low Permeability Soil - General:
   1. Contractor shall provide natural, fine-grained soil or bentonite amended soil that is capable of being worked to produce a soil layer of thickness shown on the drawings that has a saturated hydraulic conductivity of 1.0 x 10-7 cm/sec or less, as determined by ASTM D5084.
   2. The potential existence of on-site soil material suitable for use as the low permeability soil (natural, fine-grained soil) has not been evaluated.
   3. In accordance with these specifications, the Contractor is responsible for conducting a borrow soil characterization study (BSCS).
   4. The Contractor is encouraged to investigate all possible sources of low permeable soil including, but not limited, to on-site soils.
   5. Contractor shall provide the CQA Consultant and Owner access to information about the borrow source of the low permeability soil and certify that it is not contaminated with hazardous materials or hazardous wastes.

B. Natural Fine-Grained Soil
   1. Classification: Natural fine-grained soil shall have a classification of CH, CL, MH, or ML as determined by ASTM D2488.
   2. Grain sizes shall be within the following gradation:

Sieve Size	Percent Passing by Weight
No. 4	> 90
No. 200	> 30

No particles shall be greater than 3/4 IN in any dimension.

3. Hydraulic Conductivity: The saturated hydraulic conductivity of the natural fine-grained soil shall be less than 1.0 x 10-7 cm/sec as measured by ASTM D5084, when compacted in accordance with requirements established by the CQC Consultant and Contractor on the basis of the soil liner test strip as specified herein.
4. Other Soil Liner Properties: The liquid limit shall be at least 25 as measured by ASTM D4318. The plasticity index shall be at least 10 and less than 30 as measured by ASTM D4318.
5. Compaction Equipment:
   a. The compaction equipment shall be suitable type and adequate to obtain densities specified, and shall provide satisfactory breakdown of materials to form a low permeability fill free of lift interface voids. The CQC Consultant shall confirm compaction equipment adequacy, and recommend changes if required, based on the soil liner test strip. Such additional equipment will be provided by Contractor at no additional cost.
   b. The compaction equipment shall be maintained and operated in a condition that will deliver manufacturer's rated compactive effort.
   c. Hand-operated equipment shall be capable of achieving specified soil densities.
   d. Natural fine-grained materials shall be compacted using equipment that provides a kneading action, such as a wobble-wheeled roller or a sheepsfoot roller having tines as long as the maximum lose lift thickness to ensure proper lift interface compaction.
   e. If a sheepsfoot is used, the finished surface of the final lift shall be rolled with a smooth steel drum roller or rubber-tired roller to eliminate tine or roller marks and provide a smooth, dense surface for geomembrane placement.
6. Moisture Control Equipment: Equipment for applying water shall be of a type and quality adequate for the work, shall not leak, and shall be equipped with a distributor bar or other approved device to assure uniform application. Equipment for mixing and drying out material shall consist of blades, discs, or other equipment defined by the CQC Consultant as approved by the CQA Consultant. Mixing of natural fine-grained soils may also be required to get even distribution of moisture. Soil liner material must not be compacted within 24 hours of the adjustment of water content by the addition of water.

C. Bentonite Amended Soil (where applicable):
   1. Hydraulic conductivity of constructed bentonite amended soil

shall be 1.0 x 10-7 cm/sec or less when compacted in accordance with requirements established by the CQC Consultant on the basis of test results from the soil liner test strip and the soil borrow source investigation.

2. Soil used in the bentonite amended soil shall be free from roots, organic matter, debris, particles larger than 3/4 IN, and other deleterious material. All soil used in the bentonite amended soil shall be taken from a borrow area approved by the CQC Consultant.
3. Unless approved otherwise by the CQC Consultant, the soil used in the bentonite amended soil shall meet the following washed sieve gradation:

Sieve Size	Percent Passing by Weight
3/4IN	100
No. 4	55-100
No. 20	45-75
No. 200	10-40

4. Bentonite:
   a. Bentonite shall be free-flowing, powdered, high-swelling, sodium montmorillonite clay (bentonite) free of additives.
   b. Acceptable bentonite manufacturers are:
      1) Bentonite Corp.
      2) CETCO.
      3) MI Bentonite.
      4) WYO-BEN.
   c. The Contractor may propose a bentonite supplier other than those listed above if it is demonstrated that its use in the amended soil satisfies the requirements of these specifications.
5. Bentonite Amended Soil Mixing equipment (where applicable):
   a. Contractor shall mix, process, and condition the bentonite amended soil in a pugmill prior to placing and compacting the mixture.
   b. The pugmill shall have the capability to break up soil clumps and mix material to form a homogeneous blend. The pugmill shall have controls that allow a variable rate of discharge from it, to control the degree of mixing. The pugmill shall have automated controls to control the rate of feed of each material to within an accuracy of 2 percent by weight.
   c. The pugmill discharge shall be equipped with a batching bin having a drop outlet for loading hauling vehicles directly from the he pugmill. Pugmill shall be positioned to allow direct discharge to hauling vehicles.
   d. Contractor shall not store amended soil in a manner or for a length of time that will cause any degradation of the

project or amended soil.

6. Compaction Equipment:
   a. Compaction equipment shall be a suitable type and adequate to obtain soil densities specified by the CQC Consultant based on the soil liner test strip.
   b. Contractor shall maintain and operate equipment in such condition that it will deliver manufacturer's rated compactive effort.
   c. Hand-operated equipment shall be capable of achieving specified densities.
   d. Contractor shall compact bentonite amended soil using a pneumatic, tire roller or a sheepsfoot compactor.
7. Moisture Control Equipment: Equipment for applying water shall not leak, and shall be equipped with a distributor bar or other device to assure uniform application as approved by the CQC Consultant.

2.02 SOIL LINER MATERIAL ACCEPTANCE

A. General: All imported, on-site, and processed materials specified in this section are subject to the following requirements:
   1. All tests necessary for the Contractor to locate and define acceptable sources of materials shall be made by the CQC Consultant. Certification that the material conforms to the Specification requirements along with copies of the test results from a qualified commercial testing laboratory shall be submitted to the CQA Consultant for approval at least 10 days before the material is required for use. All material samples shall be furnished by the Contractor at the Contractor's sole expense.
   2. All samples required in this section shall be representative and be clearly marked to show the source of the material and the intended use on the project. Sampling of the material source shall be done by the CQC Consultant in accordance with ASTM D75.
   3. Notify the CQA Consultant at lease 24-hours prior to sampling. The CQA Consultant may, at the CQA Consultant's option, observe the sampling procedures.
   4. Tentative acceptance of the material source shall be based on an inspection of the source by the CQA Consultant and the certified test results of the Borrow Source Characterization Study (BSCS) as submitted by the Contractor to the CQA Consultant. No imported materials shall be delivered to the site until the proposed source and materials tests have been accepted in writing by the CQA Consultant.
   5. Final acceptance of any material will be based on results of tests made on material samples taken from the completed soil liner test strip, combined with the results of the BSCS. If tests conducted by the CQC Consultant or the CQA Consultant indicate that the material does not meet Specification requirements, material placement will be terminated until corrective measures are taken. Material which does not conform to the Specification requirements and is placed in the work

shall be removed and replaced at the Contractor's sole expense.

6. Contractor shall be solely responsible for obtaining all permits required to obtain acceptable sources of materials for use in the work.

B. Sampling and testing required herein shall be done at the Contractor's sole expense.

C. Low Permeability Borrow Source Characterization Study:

1. The Contractor will be responsible for all processing and screening of the soil liner material at his own cost to meet the requirements of the specifications. The Contractor will be responsible for the erosion protection of the stockpile during his operation. The Contractor shall coordinate all aspects of this operation with the CQC Consultant, CQA Consultant, and Project Manager.
2. CQC Consultant shall complete a BSCS of natural fine-grained soils or of soil that will be used in bentonite amended soils.
3. Contractor shall conduct tests, including particle size, Atterberg limits, moisture-density, and hydraulic conductivity tests, as necessary to locate an acceptable source of material.
4. Once a potential source of material has been located, the CQC Consultant shall develop and undertake a testing program to demonstrate the acceptability of the proposed material. Certified results of all tests shall be submitted to the CQA Consultant upon completion of tests. Tentative acceptance of the borrow source by the CQA Consultant will be based upon the results of the study. The testing program shall include the following elements, at a minimum:
   a. An excavation plan for the borrow source indicating proposed surface mining limits and and depths of samples to be taken for testing.
   b. Test pits for borrow source sampling shall be appropriately spaced to reflect site geomorphology and sampled at depth intervals appropriate to the proposed excavation methods.
   c. A minimum of 12 samples shall be collected and tested for the parameters required as described in the following paragraphs.
5. Test Parameters and Reporting for Natural Fine-grained Soils: All samples collected from the proposed borrow area for natural fine-grained soils shall be tested for the following parameters:

Parameter	Test Method
Particle Size (sieve plus hydrometer)	ASTM D422
Atterberg Limits	ASTM D4318
Moisture-Density	ASTM D698

Hydraulic Conductivity(1)	ASTM D5084	

(1) Hydraulic conductivity tests shall be performed on recompacted samples of the proposed material, compacted according to criteria developed by the CQC Consultant using data from tests conducted in accordance with ASTM D698.

6. Test Parameter for Soil to be Used in Bentonite Amended Soil:
   a. Parameters and reporting for soils to be used in bentonite amended soil shall be the same as for natural fine-grained soil.
   b. Tests required under this paragraph are part of the BSCS. Additional tests on the bentonite amended soil product are required for soil liner acceptance. See 2.01E.

D. Natural Fine-Grained Soils Conformance Testing:
   1. Following acceptance of a source for natural fine-grained soils, the following tests shall be performed by the CQC Consultant on samples taken from the excavated soil liner material using the methods and at the frequencies indicated below:

Test	Test Method	Minimum Frequency
Percent Fines	ASTM D422	1 per 5,000 cu yd
Atterberg Limits	ASTM D4318	1 per 5,000 cu yd
Moisture-Density	ASTM D698	1 per 10,000 cu yd

   2. The CQC Consultant shall conduct tests more often if variation in test results is occurring, or if material appears to depart from Specifications.
   3. The CQA Consultant may also conduct independent tests to confirm the accuracy of the testing conducted by the CQC Consultant.
   4. If tests indicate material does not meet Specification requirements, Contractor shall terminate material placement until corrective measures are taken.
   5. Contractor shall remove and replace material which does not meet Specification requirements at no additional cost to the Owner.

E. Bentonite Amended Soil Conformance Testing:
   1. Following acceptance of a source for soils to be used in bentonite amended soils, the CQC Consultant shall perform a Design Mix Analysis and submit certifications for the imported bentonite material as described below.
   2. Design Mix Analysis:
      a. Collect two of the coarsest samples of the soil taken from the approved borrow area (based on percent retained on

#200 sieve). Soil samples for testing shall be as least 100 pounds each.

b. Trial mix samples shall be prepared by mixing each soil sample with three trial application rates of bentonite. Compact each trial mix sample to a dry density equal to 95 percent relative compaction and at a moisture content within the range of optimum to optimum plus 3 percent (ASTM D-698) for the unamended soil.

c. Test the hydraulic conductivity of the trial mix samples using ASTM D5084 and report all data to CQA Consultant. Graph measured hydraulic conductivity vs. percent bentonite.

d. Contractor shall select a minimum bentonite content needed to consistently achieve an in-place hydraulic conductivity of 1.0 x 10-7 cm/sec or less as measured by ASTM D5084.

3. As soil to be used in bentonite amended soil is excavated from the borrow source, the following tests shall be performed by the QC Consultant at the frequencies and using the methods indicated below.

Test	Method	Minimum Frequency
Percent Fines	ASTM D1140	1 per 5,000 cu yd
Moisture-Density	ASTM D698	1 per 10,000 cu yd
Atterberg Limits	ASTM D4318	1 per 5,000 cu yd

4. After selection of a mix design, compaction tests shall be performed according to ASTM D698 or D1557 depending on the compaction equipment to be used. The compaction test will provide the dry density at 95% maximum compaction and optimum moisture content.

5. After mix design and initial testing, CQC Consultant shall conduct tests of the mixed bentonite amended soil, after it has been discharged from the pugmill and before this is placed in the work using the following methods and at the following frequencies.

Test	Method	Minimum Frequency
Particle Size Analysis	ASTM D422	1 per 5,000 cu yd
Moisture-Density	ASTM D698	1 per 10,000 cu yd

6. Bentonite: CQC Consultant shall submit certifications from the supplier of the bentonite material that it meets the requirements specified under PART 2, PRODUCTS.

F. Fine-Grained Material Dewatering, Mixing, and Staging

1. Dewatering of soil liner borrow excavations, if required, shall

be solely at the Contractors expense.

2. Drying, blending, or wetting required to maintain the soil liner soil at a suitable moisture content shall be solely at the Contractors expense.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The subgrade to be lined shall be smooth and free of vegetation, sticks, roots, and debris. It shall be the responsibility of the Contractor to keep the receiving surfaces in the accepted condition until complete installation of the liner is accomplished.

B. The subgrade shall be proofrolled with a pneumatic tired vehicle of at least 20 tons GVW, making passes across the area as directed by the CQC and/or CQA Consultants. The soil liner shall not be placed over areas deemed unacceptable by either the CQC or CQA Consultants based on proofroll observations or inadequate test results.

C. The soil liner shall be installed in four compacted lifts of approximate equal thickness.

D. When particles exceeding 3/4" are observed at the final lift surface, they shall be removed by hand prior to final rolling of the surface.

E. Equipment shall be used such that bonding of the two lifts will occur. Equipment shall have cleats or other protrusions of such length necessary to completely penetrate into the loose lift. Compaction shall be performed using appropriately heavy, properly ballasted, penetrating foot compactor making a minimum number of passes as approved by the CQC Consultant and CQA Consultant based on the soil liner test strip.

F. If desiccation and crusting of the lift surface occurs prior to placement of the next lift, this area shall be scarified to a minimum depth of two inches or until sufficiently moist materials are encountered, whichever is greater. After scarification, the superficial material should be reworked to obtain a moisture content at least two percent above optimum moisture content. Alternately, the drier superficial soil may be stripped and mixed with additional moist soil to achieve a moisture content satisfying the project requirements.

G. No frozen material shall be placed.

H. Material shall not be placed on a previous lift which is frozen. Frozen in-place material shall be removed prior to placement of additional soil material.

I. Material which has been subjected to a freeze/thaw cycle(s) shall be disked and recompacted prior to placement of subsequent lifts.

J. During construction, exposed finished lifts of the soil liner material should be sprinkled with water to minimize desiccation, as necessary. The Contractor is responsible to protect the soil liner from rain, drying, desiccation, erosion and freezing. All defective areas shall be repaired by the Contractor to the satisfaction of the CQC Consultant at no extra compensation.

K. At the end of each day's construction activities, completed lifts or sections of the compacted soil liner should be sealed. Common sealing methods include rolling with a rubber tired or smooth-drum roller, backdragging with a bulldozer, or placement of temporary cover soil over the compacted soil liner. The compacted soil liner should be sprinkled with water, as needed.

L. If testing shows that a lift is significantly thicker than six inches, the top of the lift will be shaved off so that the lift is approximately six inches thick.

3.02 SOIL LINER TEST STRIP

A. Test Strip Installation:

1. Prior to actual soil liner installation, a soil liner test strip of a dimension no less than 100 feet long by 30 feet wide by 2 feet thick shall be constructed by the Contractor over a compacted subgrade within the liner construction site.
2. The soil liner test strip shall be constructed using the same equipment and construction procedures that are anticipated for use during actual liner installation.
3. During test strip installation, the Contractor in coordination with his CQC Consultant and the CQA Consultant shall determine the field procedures that are best suited for his construction equipment to achieve the requirements specified herein.
4. If the test strip fails to achieve the desired results, the soil material of the strip shall be completely removed, and additional test strip(s) shall be constructed until the requirements are met.
5. The CQC Consultant shall document that the subgrade of the test strip liner is properly compacted to at least 95 percent of the maximum dry density, as determined using the Standard Proctor test (ASTM D-698). Field density tests on the subgrade shall be performed by the CQC Consultant and documented at a minimum of three test locations within the test strip area.
6. At least five field density measurements shall be performed by the CQC Consultant on each lift of the liner test strip. The field density tests shall be conducted using a nuclear gauge (ASTM D-2922) or other method, as approved by the CQA Consultant. Corresponding tests for moisture content to determine dry density shall likewise be performed by using a nuclear gauge (ASTM D-3017), or other approved method. On the

test pad, the density measurement if performed by a nuclear gauge shall be verified through performance of one sand cone tests (ASTM D-1556) or drive tube test (ASTM D-2937) at a location selected by the CQA Consultant. The moisture content measurement, if performed by a nuclear gauge shall be verified by recovering at least five samples for oven-dry testing (ASTM D-2216) from the test location.

7. Upon completion of the soil liner test strip, the CQC Consultant, as observed by the CQA Consultant, shall measure the thickness of the test strip at a minimum of five random locations.

8. A minimum of five random samples of the liner construction materials delivered to the site during test strip installation shall be tested by the CQC Consultant for moisture content (ASTM D-2216), sieve analyses (ASTM D-421, D-422) and Atterberg limits (ASTM D-4318).

9. The CQC Consultant shall conduct at least one standard Proctor (ASTM D-698) and one modified Proctor (ASTM D-1557) compaction test on bag samples of the test strip material to determine the moisture-density relationships.

10. A minimum of five undisturbed samples shall be taken from the test strip by the CQC Consultant for laboratory hydraulic conductivity testing. The samples shall be taken within a two-foot radius of the in-situ density and moisture tests. The CQA Consultant may also conduct independent hydraulic conductivity testing. Laboratory hydraulic conductivity testing shall be conducted using constant head, triaxial type permeameters (ASTM D-5084). The test specimens shall be consolidated under an isotropic effective consolidation stress determined by the CQA Consultant and permeated with water under a back pressure of at least 10 pounds per square inch (psi) to achieve saturation. The inflow to and outflow from the specimens shall be monitored with time and the coefficient of permeability calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of coefficient of permeability are measured.

11. Optional: The data gathered from the test strip sampling (i.e., field density, moisture, undisturbed samples, and in-situ hydraulic conductivity) shall be used along with the Proctor curve for the soil to develop a range of acceptable moisture and density test values which are likely to result in a maximum permeability no greater than 1 x 10-7 cm/sec. This range of moisture/density values will be established by the CQC Consultant and the CQA Consultant and will be utilized as a means to establish Pass/Fail Criteria for the remainder of the area to be lined by the subject material.

12. The test strip will be considered acceptable if the measured hydraulic conductivity of the test strip as determined by ASTM D-5084 meets the requirements of the specifications.

13. If field and laboratory test data indicate that the installed test strip meets the requirements of this Specification, it may be used as part of the liner provided that it is adequately

protected by the Installer from drying and equipment damage after installation. The Installer shall scarify the liner material along the edge of the test strip. A minimum 2-foot overlap per lift is required for mixing and compaction between the test strip and the liner.

14. Upon receipt of the test data from the CQA Consultant, the Project Manager shall inform the Contractor if the test strip can remain in-place as part of the liner.

3.03 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. Refer to the CQA Plan.

B. The following field and laboratory quality control tests shall be performed by the CQC Consultant at no additional expense to the Owner during soil liner construction:

1. Density/Moisture: Conduct at least one field density test per 100' x 100' grid area per lift of compacted liner. Field density tests shall be conducted using a nuclear gauge (ASTM D-2922), or other method as approved by the CQA Consultant. Corresponding tests for moisture content to determine dry density shall likewise be performed using a nuclear gauge (ASTM D-3017), or other approved method. As a check of the nuclear methods, perform one drive tube density (ASTM D-2937) determination once for every fifty nuclear tests and a series of five oven-dry (ASTM D-2216) samples after each set of 25 nuclear moisture content tests.
2. Thickness: Using a 1 IN auger and/or probe at a frequency no less than four tests per acre per lift of installed soil liner measure the thickness of the soil liner. Thickness measurements shall be observed by the CQA Consultant.
3. Atterberg Limits: Perform Atterberg Limits on at least one sample per acre per lift of installed liner. This may be waived by the CQA Consultant if permeability requirements are being met.
4. Fines Content: Determined at a minimum frequency of one test (ASTM D-1140) per acre per lift of installed liner.
5. Hydraulic Conductivity (ASTM D-5084): Test at a minimum frequency of one test per acre per lift.
6. Laboratory Compaction Tests: Re-evaluated after each increment of 5,000 cubic yards is placed.
7. If there are indications of a change (e.g., visual appearance) in product quality between shipments, additional tests shall be performed as necessary.
8. Holes in the compacted soil liner created as a result of destructive testing (i.e., thin-walled shelby tube sampling, field density determinations and thickness measurements) shall be backfilled and tamped by rod uniformly in 2 inch thick lifts. The backfill material shall be the same liner construction material or hydrated bentonite powder, if approved by the CQA Consultant. On the surface, the backfill material shall extend slightly beyond the holes to make sure that a good tie in with the surrounding liner is achieved. Repaired areas

shall be observed and documented by the CQC Consultant.

B. Give minimum of 24 HR advance notice to CQA Consultant when ready for soil testing and inspection in completed area of the soil liner.

C. For areas not meeting field and laboratory testing criteria, the Contractor shall scarify the full depth of the lift or replace the material as needed. The material shall be reshaped, rewetted as needed, rehomogenized and recompacted to the specified density. Areas not meeting the thickness requirements shall be augmented with additional materials. The added materials shall be reworked with the soil layer to ensure homogeneity and proper bonding. This may be done by scarification of the surface prior to addition of new material. The repaired area shall be properly documented, and field and laboratory quality control testing shall be performed to ensure the repaired liner section meets the requirements specified herein.

D. The Contractor shall pay for all costs associated with corrective work and retesting resulting from failing compaction density tests.

E. The soil liner materials on the landfill base shall be compacted to no less than 95 percent of the Standard Proctor (ASTM D-698) dry density corresponding to the molding moisture content.

END OF SECTION

SECTION 02515

HDPE MANHOLE STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION

A. General:
1. Furnish all labor, materials, tools, equipment and services for all manhole structures with appurtenant items and pipe in accordance with provisions of the Contract Documents.
2. Completely coordinate with work of all other trades.
3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

B. Work included consists of, but is not necessarily limited to:
1. Leachate management devices and manholes.

C. Related Sections include, but are not necessarily limited to:
1. Section 02221 - Trenching, Backfilling and Compacting
2. Section 02775 - Geosynthetic Liner System.
3. Section 03002 - Concrete.
4. Section 15060 - Pipe and Pipe Fittings: General.
5. Section 15064 - Pipe: Plastic.
6. CQA Plan.

1.02 QUALITY STANDARDS

A. Referenced Standards:

ASTM D- 883	Definition of Term Relating to Plastics
ASTM D-1248	Specification for Polyethylene Plastics Molding and Extrusions Materials
ASTM D-2122	Determining Dimensions of Thermoplastic Pipe and Fittings.

1.03 SUBMITTALS

A. See Section 01300.

B. Include detailed diagrams for manholes showing components and dimensions.

C. Indicate elevation and position of all piping and appurtenances of each manhole.

D. Provide fabrication drawings indicating proposed welding procedures, bracing, and other pertinent information regarding manhole construction.

E. Production Dates: Submit statement of production dates for the resin and the geosynthetic for this work.

F. Factory Test Results and Material Certification: Submit factory test results of materials demonstrating conformance with the requirements of these Specifications. In addition, submit the Manufacturer's certification that the material delivered is similar and the same formulation as that for which test results are submitted. Submittal shall be prior to or concurrent with product delivery.

G. Butt-fused welds created at the factory shall be ultra-sonically tested or by some other appropriate means, as approved by the Project Manager. A written certification of the test results shall be submitted by the manufacturer, prior to delivery to the job site.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Manholes:
      a. Advanced Drainage Systems, Inc. (ADS)
      b. Driscopipe 1000
      c. Spirolite by Chevron
      d. Approved equal
   2. Pipe (If used for manhole construction)
      a. Driscopipe 1000
      b. Polypipe PE 3408
      c. Plexco by Chevron
      d. Approved equal

2.02 MANHOLES AND APPURTENANCES AND PIPE

A. Materials:
   1. Manholes: Polyethylene Manholes shall be produced using polyethylene compounds conforming to the requirements of Type III, Category 5, Grade P34, Class C, as defined and described in ASTM D-1248. Clean reworked material or reprocessed material may be used in the manufacture provided that the manhole components meet all of the requirements of this product specification. Manholes may be constructed of factory seamed pipe if the size and SDR are available. In that case, pipe criteria in these specifications applies.
   2. Pipe: High Density Polyethylene Pipe, solid wall shall conform to requirements of ASTM D-1248 Classification Type III, Class C, Category 5, Grade P34; ASTM D-3350 Classification PE345434C. The pipe shall conform to SDR rating as depicted on the drawings.

B. Manufacture:

1. Manholes shall be produced in the rotational molding process. The manhole will consist of an appropriate combination of base, elevation, and top section based on project requirements.
2. Manholes shall be completely constructed, including all outlets, and appurtenances at the facility which manufactures the manhole. Field fabrication of any manhole components by the Contractor is not acceptable.
3. Manholes shall be designed so that a portable ladder can be supported by the installed manhole.
4. The bottoms of the manholes shall be 2" thick and butt-fused to the manhole body.
5. Manway reducers if applicable shall be eccentric with respect to the larger portion of the manhole.

C. Requirements:

1. Workmanship: Exterior and interior surfaces shall be relatively smooth with no sharp projections. The surfaces shall be free of foreign inclusions and major surface defects. Polyethylene pipe shall be as uniform as commercially practical in color, opacity, density, and other physical properties. The product function shall be considered when judging external defects.
2. Dimensions: As depicted on the drawings.
3. Wall Thickness: Wall thickness of all components shall be determined in accordance with ASTM D-2122 and shall have a minimum standard dimension ratio of 32.5, or as shown on the plans.
4. Fabrication: Inlet and outlet openings and connecting devices may be fabricated utilizing extrusion welding techniques. Fittings, gaskets, and accessories shall be chemically compatible with leachate and be as recommended by the manufacturers of the manhole segments.
5. Compressive Strength: Manholes shall have compressive strength which shall be determined in accordance with ASTM D-2412 modified pipe stiffness test. Pipe stiffness values shall be 12 psi min. at 5% deflection, including joints. Axial compressive strength shall exceed 10,000 pounds at deflection less than 3%.

2.03 SOURCE QUALITY CONTROL

A. Tests and Inspections

1. Each manhole shall be permanently labeled at the factory.
2. Each manhole shall be factory tested and certified water tight.
3. Each manhole, upon delivery to the site, shall be accompanied with factory test certification.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall examine and verify conditions affecting installation of the manholes prior to commencing work.

3.02 INSTALLATION/ERECTION

A. Manholes
   1. Install in 12" leveling bed of crushed rock or gravel.
   2. Concrete shall be placed around the manhole in the annular space between the outside surface and the excavation to the dimensions shown on drawings.
   3. Install plumb and to grade for entering and exiting piping.
   4. Exercise care to protect in entering and exiting piping.

B. Pipe
   1. Install as indicated on the drawings.
   2. Install to line and grade as indicated.
   3. Only the butt fusion welding of solid pipe is acceptable.
   4. Pipe penetrations through the liner shall only be made by using prefabricated pipe boots.

3.03 QUALITY ASSURANCE AND QUALITY CONTROL

A. The CQA Consultant shall inspect manholes prior to installation for physical damage and report to the Project Manager.

B. The Contractor shall develop and submit schedule for testing of manholes and appurtenant piping.

C. Tests shall be witnessed by the CQA Consultant.

D. The Contractor shall hydrostatically test each manhole and header pipe section by filling with water and securing the opening to prevent evaporation. Duration of test shall be 48 hours.

E. Manholes and piping will be accepted if no water is lost during the 48 hour test period, at the discretion of the Project Manager or CQA Consultant.

F. Manholes and piping which leak shall be repaired by the Contractor at no additional cost to the Owner.

END OF SECTION

SECTION 02775

HDPE GEOMEMBRANE LINER SYSTEM

PART I - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of an impermeable, HDPE geomembrane liner as shown on drawings and specified in accordance with provisions of the Contract Documents.
   2. Completely coordinate work with that of all other trades.
   3. Work items in project include, but are not necessarily limited to, the liner for the landfill lateral expansion.
   4. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.
   5. Furnish CQC Consultant to monitor work of Geomembrane Installer and to perform CQC testing in accordance with provisions of the Contract Documents.
   6. The Contractor, Geomembrane Installer, and CQC Consultant are required to attend the CQA/CQC Resolution Meeting and the CQA/CQC Preconstruction Meeting, Section 01200.

B. Related Sections include but are not necessarily limited to:
   1. Section 02220 - Earthwork.
   2. Section 02221 - Trenching, Backfilling and Compacting.
   3. Section 02240 - Leachate Collection System
   4. Section 02276 - Soil Liner System.

1.02 QUALITY STANDARDS

A. Referenced Standards:
   1. American Society for Testing and Materials (ASTM).
      a. ASTM D-638 Standard Test Method for Tensile Properties of Plastics
      b. ASTM D-751 Standard Test Method for Coated Fabrics
      c. ASTM D-792 Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement
      d. ASTM D-1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
      e. ASTM D-1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
      f. ASTM D-1603 Standard Test Method for Carbon Black in Olefin Plastics
      g. ASTM D-3015 Standard Practice for Microscopic Examination of Pigment Dispersion in Plastic Compounds, Refer to

Subpart 2.02 for property to be tested.

2. National Sanitation Foundation (NSF) Standard No. 54.
3. The Geosynthetic Research Institute (GRI).
   a. GRI GM5(a) Notched Constant Tensile Load (NCTL) Test for Polyolefin Geomembranes
   b. GRI GM6 Pressurized Air Channel Test for Dual Seam Geomembranes.
4. The accompanying CQA Plan, prepared by HDR Engineering.

B. Qualifications:
   1. Each geomembrane Manufacturing or Installation firm shall demonstrate 5 years continuous experience, including a minimum of 10,000,000 SF of HDPE geomembrane manufacture or installation.
   2. Geomembrane Installer Personnel Qualifications: Installation Superintendent shall have worked in a similar capacity on at least five HDPE geomembrane liner jobs similar in size and complexity to the project described in the Contract Documents. The Master Welder shall have completed a minimum of 5,000,000 square feet of HDPE geomembrane seaming work using the type of seaming apparatus proposed for use on this Project. Other welders shall have seamed a minimum of 1,000,000 square feet of HDPE geomembrane.
   3. The CQC Consultant shall meet the qualification requirements of Section 01410 of these Specifications.

C. CQA PLAN IMPLEMENTATION - Construction Quality Assurance for the HDPE geomembrane installation will be performed for the Owner by the CQA Consultant in accordance with the CQA Plan prepared for this project. The work performed under the CQA Plan is paid for by the Owner and is not a part of this contract. The Contractor, CQC Consultant, and Geomembrane Installer, however, should familiarize themselves with the CQA Plan and are responsible for providing reasonable notice of and access to work elements that the CQA Consultant is required by the CQA Plan to overview.

1.03 SUBMITTALS

A. Submit for Engineer's approval prior to placement of geomembrane liner, including:
   1. Manufacturer's Submittals.
      a. Manufacturer's Quality Control (MQC) Program: Submit for review a complete description of the geosynthetic Manufacturer's formal quality control program for manufacturing HDPE geomembrane. The MQC program shall include as a minimum:
         1) Testing of incoming resin prior to manufacture of geomembrane at a frequency of not less than one per hopper. This testing shall include the following tests and minimum criteria:
            - Specific Gravity (ASTM D792 Method A or ASTM D1505): >0.935.
            - Melt Index (ASTM D1238 Condition 190/2.16):

1.0g/10 min.

2) Routine testing of the manufactured sheet for physical parameters to confirm that the geomembrane meets or exceeds these Specifications (2.02 A.4). Testing for carbon black content and dispersion, tensile strength, and elongation properties shall be at a frequency of not less than one per 40,000 SF of geomembrane. Testing for environmental stress crack resistance shall be at a frequency of not less than one per 400,000 SF of geomembrane. Thickness shall be monitored continuously through the manufacturing process, or measured physically at a frequency of not less than once per 1,000 SF of geomembrane.

3) Extrusion rod. Extrusion rod shall be manufactured from identical resin to that used in geomembrane manufacture. Manufactured extrusion rod shall be tested for carbon black content and dispersion, specific gravity and melt index at a frequency of not less than one test per batch.

4) The Manufacturer shall reject resin and geomembrane that do not conform with the requirements of the approved MQC program.

5) MQC data shall accompany the geomembrane shipment.

b. Manufacturer's Field Installation Procedures Manual: Submit complete geomembrane Manufacturer's specifications, descriptive drawings, and literature for the recommended installation of the HDPE geomembrane liner system, including recommended methods for handling and storage of all materials prior to installation, and field installation guidelines that the manufacturer feels are relevant and important to the success of this project. At a minimum, the manual shall include the following provisions with exceptions noted by the Manufacturer:

1) Geomembrane shall not be placed upon standing water or other conditions which will result in deterioration of the CSL.

2) The Geomembrane Installer shall remove any materials placed to protect the CSL prior to placement of the geomembrane liner.

3) Adjacent rolls of geomembrane shall overlap a minimum of 4 IN.

4) Geomembrane liner shall be handled and placed in a manner which minimizes wrinkles, scratches, and crimps.

5) Geomembrane liners shall be welded using either extrusion or radiant wedge welding equipment. Each piece of welding equipment and each operator shall perform demonstration welds at the start of a shift, whenever equipment is switched on, and at other times at the discretion of the CQC Consultant. These demonstration welds shall be tested using daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, and equipment on site using field tensiometer and, at a minimum,

exhibit seam shear strength of greater than 128 LBS per inch of width (smooth), 113 lbs per inch of width (textured) and seam peel shear strength of greater than 98 LBS per inch of width (smooth), 88 lbs per inch of width (textured).

6) Surfaces to be welded shall be clean and dry at the time of welding. Geomembrane shall not be welded when ambient temperatures are below 40 Deg F (5 Deg C) or above 104 Deg F (40 Deg C) unless the Geomembrane installer can demonstrate that the seam quality is not compromised.

7) Geomembrane liners shall be welded continuously without fishmouths or breaks in the weld. Where fishmouths are unavoidable, the geomembrane sheet shall be slit to a point such that the sheet lies flat and with no remaining wrinkle. The two edges of the slit shall be welded together provided that the overlap for this weld shall be a minimum of 3 IN. Areas of the slit which do not achieve an overlap of 3 IN, including the terminus of the slit, shall be provided with a patch as discussed below.

8) Defects in and damage to geomembrane sheets shall be repaired by welding a patch over the defect using extrusion welding equipment. The patch material shall consist of an undamaged piece of geomembrane cut to provide a minimum of 3 IN of overlap in all directions from the defect. Torn or permanently twisted geomembrane shall be replaced at no expense to the Owner.

9) Personnel walking on the geosynthetic shall not engage in activities or wear types of shoes, that could damage the geosynthetic. Smoking shall not be permitted while working on the geomembrane.

10) Vehicular traffic directly on the geosynthetic shall not be permitted. Equipment shall not damage the geosynthetic materials by handling, trafficking, leakage of hydrocarbons, or any other means. The unprotected geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses.

c. Manufacturer's Material Data: Prior to shipment of geomembrane, submit quality control certificates for each roll demonstrating conformance with the requirements of these Specifications. Submit statement of production dates for the resin and the HDPE geomembrane for this work.

d. Manufacturer's written acceptance of Geomembrane Installer's qualifications for installation of the HDPE geomembrane.

e. Warranty: Submit a warranty signed by the Manufacturer. The warranty shall be against manufacturing defects and workmanship and against deterioration due to ozone, ultra-violet, and other exposure to the elements, for a period of 20 years on a pro rata basis. The warranty shall be limited

to replacement of material, and shall not cover installation of replacement geomembrane.

2. Geomembrane Installer's Submittals.
   a. The Geomembrane Installer will submit written documentation that their personnel satisfy the qualifications of 1.02 B.
   b. Geomembrane Installer's Construction Quality Control Program: Submit for review a complete description of the Geomembrane Installer's formal construction quality control programs to include, but not be limited to, product acceptance testing, installation testing, including both non-destructive and destructive quality control field testing of the sheets and seams during installation of the geomembrane, proposed methods of testing geosynthetic joints and connections at appurtenances for continuity, documentation and changes, alterations, repairs, retests, and acceptance.
   c. Geomembrane Installer's Installation Procedures Manual: submit for approval the Installer's installation manual to include: ambient temperature at which the seams are made, control of panel lift up by wind, acceptable condition of the subsurface beneath the geomembrane, quality and consistency of the welding material, proper preparation of the liner surfaces to be joined, cleanliness of the seam interface (e.g., the amount of airborne dust and debris present), and proposed details for connecting the HDPE liner to appurtenances, i.e. penetrations of the containment facilities. The document shall include a complete description of seaming by extrusion welding and hot-wedge welding. The Geomembrane Installer's Installation Manual will by reference include requirements of the Manufacturer's Installation Manual unless exceptions are noted and approved by the Engineer. After this manual has been approved by the Engineer, the Geomembrane Installer shall not deviate from the procedures included in the manual.
   d. Geomembrane panel layout with proposed size, number, position and sequencing of panels and showing the location and direction of all field joints.
   e. Warranty: The Geomembrane Installer shall agree in writing to warranty the geomembrane system to be free of defects for a period of 2 years following the date of acceptance of the work performed under this contract.
3. CQC Consultants Submittals:
   a. CQC Consultant shall submit written documentation that their personnel satisfy the qualifications of Section 01400.
   b. CQC Consultants CQC Geomembrane Manual: Submit CQC Consultant's written program for meeting the geomembrane material conformance and CQC requirements of these Specifications.
4. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted. All submittals must be submitted prior to the Geomembrane Preconstruction Meeting, Section 01200.

D. Submittals for Engineer's Approval Required for Final Acceptance of HDPE Geomembrane Liner System:

1. Geomembrane Installer's Submittals.

a. Warranty: Submit a warranty signed by the Geomembrane Installer that the installed geomembrane liner, attachments and appurtenances are free of defects in material, manufacturing, and workmanship.

b. Record Drawings: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identity and location of each repair, cap strip, penetration, boot, and sample taken from the installed geosynthetic for testing.

c. Welder Certification: Submit certification for each welder and performance records that include linear feet of weld completed, number of samples tested, and test failure rate for each welder. Submit field notes with daily equipment reports.

2. CQC Consultant's Submittals.

a. Certification: Submit written certification that the geomembrane liner was installed in accordance with this Specification and with the approved shop drawings.

b. CQC Records: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.

c. CQC Weld Test Summary Report: The CQC Consultant shall submit a report showing normal distribution of all CQC seam test results, identifying the high, low, and average of the five coupon samples in each test.

3. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted.

1.04 PROJECT CONDITIONS

A. When the weather is of such a nature as to endanger the integrity and quality of the installation, whether this is due to rain, high winds, cold temperatures, or other weather elements, the installation of the geomembrane shall be halted at the direction of, or with the concurrence of, the Owner until the weather conditions are satisfactory.

B. The Contractor shall insure that adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt on geosynthetic surfaces which hamper the efficient field seaming of geosynthetic panels.

C. The Contractor shall maintain natural surface water drainage diversions around the work area and provide for the disposal of water which may collect in the work area directly from precipitation falling within the area or from inadequate diversion structures or practices.

D. The Contractor shall be responsible to coordinate the installation of the leachate collection system which shall be in accordance with Geomembrane Installer's Installation Manual and as specified in these Specifications and shown on the Contract Drawings.

E. Vehicles will not be allowed on the liner area unless at least 24 inch (24") of cover has been placed over the liner except as noted in these Specifications.

F. Vehicles larger than one and one-half ton pick up trucks are prohibited on the exterior berms. Contractor shall repair any damage to exterior berms prior to final payment.

1.05 DEFINITIONS

A. Geomembrane Manufacturer: Manufacturer of geomembranes produces geomembrane sheets from resin and additives. The manufacturer is responsible for producing geomembrane sheet which complies with these Specifications. These responsibilities include but are not limited to:
   1. Acceptance of the resin and additives from chemical formulators. Testing of the raw resin and additives to ensure compliance with the manufacturer's specifications and with this Specification.
   2. Formulation of the resin and additives into geomembrane sheeting using mixing and extrusion equipment.
   3. Testing of the geomembrane sheet to ensure compliance with manufacturer's specification and this Specification.
   4. Shipping of the geomembrane sheet to Installer designated facilities.
   5. Certification of the raw materials and finished geomembrane sheet to comply with this Specification.
   6. Certification of installer's training, experience, and methods for welding and inspection geomembrane installations in compliance with manufacturer's standards.

B. Geomembrane Installer. Installer of geomembranes are responsible for handling, fitting, welding and testing of geomembrane sheets or blankets in the field. These responsibilities include but are not limited to:
   1. Acceptance (in writing) of the geomembrane from the manufacturer.
   2. Acceptance (in writing) of the CSL surface which will serve as a base for the geomembrane. This acceptance shall precede installation of the geomembrane, and shall state that the installer has inspected the surface, and reviewed the Specifications for material and placement, and finds all conditions acceptable for placement of geomembrane liners. The written acceptance shall explicitly state any and all exceptions to acceptance.
   3. Handling, welding, testing, and repair geomembrane liners in compliance with this Specification and the Geomembrane Installer's Installation Procedures Manual.
   4. Performance of QA/QC testing and record keeping as required

by the approved Geomembrane Installer's Field Installation Procedures Manual.

5. Repair or replacement of defects in the geomembrane as required by the CQC Consultant or the CQA Consultant.

D. Engineer: Responsible for approval of submittals from the Contractor.

E. CQC Consultant: Responsible for observing field installation of the geomembrane and performance of material conformance and CQC testing to provide the Contractor with verbal and written documentation of the compliance of the installation with these Specifications. The CQC Consultant reports to the Contractor and is part of this contract.

F. CQA Consultant: Responsible for implementing CQA Plan including overviewing material conformance testing, field installation of the geomembrane, and CQC activities, and to perform limited CQA conformance testing to provide Owner with verbal and written documentation of the compliance of the installation with these Specifications. The CQA Consultant will use the written results of the CQC program and the CQA program in the preparation of the facility Certification Document. The CQA Consultant reports to the Owner and is not part of this contract.

G. Refer to the accompanying CQA Plan for additional definitions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS AND/OR GEOMEMBRANE INSTALLERS

A. Subject to compliance with the Contract Documents, the following Manufacturers and Geomembrane Installers are acceptable:
   1. HDPE Geomembrane liners:
      a. GSE, Inc., 19103 Gundle Road, Houston, Texas 77073.
      b. National Seal Company, Southeast Office Route 2, Box 161, Eastanollee, Georgia 30538.
      c. The Serrot Corporation, 271 Highway 74 North, Suite 4, Peachtree City, Georgia 30269.
      d. Poly-Flex Inc., 2000 W. Marshall Drive, Grand Prairie, TX 75051.
      e. Other installers may qualify by providing references for a minimum of 10,000,000 SF of liner installations.

B. Submit requests for substitution in accordance with Specification Section 01640.

2.02 MATERIALS

A. HDPE Geomembrane Liners:
   1. Geomembrane liners shall consist of unsupported polyethylene in thickness as shown on Drawings and manufactured from virgin,

first quality resin designed and formulated specifically for liquid containment in hydraulic structures. Reclaimed polymer shall not be added to the resin; except use of polymer recycled during the manufacturing process shall be allowed provided that recycled polymer shall be clean and shall not exceed 2 percent by weight.

2. The geomembrane liner shall be manufactured to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defects shall be cause for rejection of the defective geomembrane material. Minor defects may be repaired in accordance with manufacturer's recommendations if this repair is approved by the Engineer.
3. The geomembrane liner shall be manufactured as seamless rolls or as prefabricated panels with a minimum width of 22 FT as delivered to the site. All factory seams shall be inspected and tested for strength and continuity prior to delivery to the site.
4. Geomembrane liner material shall possess properties which meet or exceed the following minimum requirements:

		TEST VALUE	
PROPERTY	TEST METHOD	SMOOTH HDPE	TEXTURED HDPE
1. Sheet Thickness, Mils	ASTM D751	57 to 63	57 to 63
2. Density (g/cc) (Minimum prior to Carbon Black)	ASTM D1238	0.934	0.934
3. Melt Flow Index g/10 min.	ASTM D1238 Condition 190/2.16	0.30-1.00	0.3-1.00
4. Minimum Tensile Properties	ASTM D638, Type IV, Dumb-bell at 2 ipm.(Each direction)		
a. Min. Tensile Strength at Break (lbs/inch)		240	75
b. Min. Tensile Strength at Yield (lbs/inch)		140	140
c. Min. Elongation at Break		700	150

	(Percent)			
	d. Min. Elongation at Yield (Percent)		13	13
5.	Min. Tear Resistance Initiation (lbs)	ASTM D1004 Die C	45	45
6.	Carbon Black	ASTM D1603	2.00-3.00	2.00-3.00
7.	Carbon Black Dispersion	ASTM D3015	A1	A1
8.	Min. Environmental Stress Crack Resistance (hrs)	ASTM D1693 Condition C	1500	1500
9.	Notched Constant Load Test	GRI GM5	Transition Time >100 Hrs @ 35% Yield	Transition Time >100 Hrs @ 35% Yield

5. No additives or fillers may be added to the resin prior to or during manufacture of the geomembrane.
6. Prior to shipment, the Geomembrane Manufacturer will provide the Project Manager and the CQC Consultant with a quality control certificate for each roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer and will include:
   a. roll numbers and identification; and
   b. the results of quality control tests.
7. The CQC Consultant will verify that a control certificate has been received for each roll and that the certified roll properties meet the requirements of these Specifications.

2.03 EQUIPMENT

A. Welding Equipment: Extrusion welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the extrudate. Radiant wedge welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the wedge. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load. Electric generators shall not be placed directly on the membrane.

B. Field Tensiometer: The Geomembrane Installer shall provide a tensiometer for on site shear and peel testing of geomembrane seams. The tensiometer shall be in good working order, built to ASTM D638 (Type IV, 2 ipm) specifications, and accompanied by evidence of

recent calibration. The tensiometer shall be motor driven and be equipped with a gauge that measures the force in unit pounds exerted between the jaws as displayed on a digital readout.

C. Vacuum Box: The Geomembrane Installer shall provide a minimum of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft closed cell neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, and a soapy solution and an applicator. The equipment shall be capable of inducing and holding a minimum vacuum of 5 psi.

D. Air Pressure Test: The Geomembrane Installer shall provide the necessary air pump and fittings required to perform the GRI GM6 air pressure test on dual seams.

E. Roll Handling Equipment: The Geomembrane Installer shall provide handling equipment that is adequate and does not pose a risk to the geomembrane rolls. The CQC Consultant shall inspect the equipment and confirm its adequacy.

PART 3 - EXECUTION

3.01 LINER SYSTEM CONSTRUCTION

A. Compacted Soil Liner (CSL) Component:
   1. The CSL component shall be constructed in accordance with Section 02276 and the Contractor shall protect the CSL from freezing, desiccation, flooding with water, and freezing.
   2. Prior to placement of the geomembrane, the CSL must be prepared as follows:
      a. Lines and grade must be verified by a Licensed Land Surveyor;
      b. The surface must be proofrolled to verify the supporting soil condition;
      c. The surface must be inspected for rocks larger than 0.75 IN; and
      d. Steel drum rolled in preparation for the geomembrane.
   3. CSL acceptance: Geomembrane liner materials shall not be placed until the required CSL preparation has been completed and the CSL has been accepted and certified in writing by the Geomembrane Installer and approved by the CQA Engineer.

B. Geomembrane Liner:
   1. The geomembrane liner shall be manufactured in accordance with the approved MQC program. The Manufacturer shall not deviate from the program without written approval of the Engineer.
   2. Transportation and handling of the geomembrane shall meet the following requirements:
      a. Transportation of the geomembrane is the responsibility of the Geomembrane Installer, Contractor, or other party as

agreed upon.

b. All handling on site is the responsibility of the Geomembrane Installer.

c. The CQC Consultant will verify that the handling equipment used on the site is adequate and will not damage the geomembrane.

d. Upon delivery to the site, the Geomembrane Installer and the CQC Consultant will conduct a surface examination of all rolls for defects or damage. This inspection will be conducted without unrolling rolls. The CQC Consultant will ensure that defective rolls are rejected and removed from the site.

e. The Geomembrane Installer will be responsible for the storage of the geomembrane on site. The Project Manager will provide a storage location on site. The Geomembrane Installer shall ensure that the storage space is adequate to protect the geomembrane from theft, vandalism, vehicular damage, etc.

3. Upon delivery of the geomembrane rolls to the site, the CQC Consultant will perform conformance testing of the manufactured geomembrane as follows:

a. Remove samples at a frequency of one test per 100,000 sq.ft. and forward to the Geosynthetics CQC Laboratory for testing to ensure conformance to these Specifications and the manufacturer's list of guaranteed properties. As a minimum, the following conformance tests will be performed:

1) Density: ASTM D792 Method A
2) Carbon black content: ASTM D1603
3) Carbon black dispersion: ASTM D2663
4) Thickness: ASTM D1593
5) Tensile strength: ASTM D368

b. All test results shall be available at the site prior to deployment of the geomembrane.

c. Samples will be taken across the entire width of the roll and will not include the first lineal 3 FT. The CQC Consultant will mark the machine direction on each sample.

d. The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQC Consultant:

1) The Geomembrane Installer will replace the roll of geomembrane that is in nonconformance with a roll in conformance with these Specifications.
2) The Geomembrane Installer will remove conformance samples for testing by the Geosynthetics CQC Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must conform to these Specifications. If either of these samples fail, then the next numerical roll will be tested until a passing roll is found.

4. Field Panel Identification: The CQC Consultant will document that the Geomembrane Installer labels each field panel with an "identification code" consistent with the approved panel layout plan. The location of the label and the color of marker used must be as agreed to in the QA/QC Preconstruction Meeting.

5. Geomembrane installation: Geomembrane liner shall be installed in accordance with the approved Geomembrane Installer's Field Installation Procedure Manual and panel layout drawing. The Geomembrane Installer shall maintain a weekly updated as-built drawing showing the location of all field panels.
6. Geomembrane Testing (Non-destructive): The Geomembrane Installer shall test and document all seam welds continuously using one of the following nondestructive seam tests:
   a. Vacuum testing shall conform to the following procedure: Brush soapy solution on geomembrane. Place vacuum box over the wetted seam area. Ensure that a leak-tight seal is created. Apply a pressure of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than fifteen (15) seconds. All areas where soap bubbles appear shall be marked and repaired as described in this Section.
   b. Air Pressure Testing (for double seam with an enclosed space) shall conform to GRI GM6 requirements.
7. Destructive Testing: The Geomembrane Installer shall field test seams destructively at a minimum frequency of one test per 500 LF of weld. Destructive testing of these samples shall also be performed by the CQC Consultant using the CQC Geosynthetics Laboratory. The CQC Consultant shall determine the location of destructive test samples. Conformance testing will be performed by the CQA Consultant in accordance with the project CQA Plan.
   a. The destructive sample shall be 16 inches wide by 42 inches long with the seam centered lengthwise. The sample shall be cut into three (3) equal parts for distribution to the Geomembrane Installer, the CQC Consultant and the CQA Consultant.
   b. All tests shall exhibit a Film Tearing Bond type of separation in which the geomembrane material tears before the weld. At least 5 coupons shall be tested by each test method. Five of five coupons shall meet minimum requirements, as specified below:

Description	Test Method	Value (lbs/in width)
60 mil Smooth HDPE Peel	ASTM D-413	98
60 mil Smooth HDPE Shear	ASTM D-816	126
60 mil Textured HDPE Peel	ASTM D-413	88
60 mil Textured HDPE Shear	ASTM D-816	113

8. Documentation: The following documentation must be maintained at the project site for review by the Project Manager or CQA Consultant:
   a. Geomembrane Installer's Documentation:
      1) Daily Log: daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, and equipment on site.
      2) Panel Log: provides geomembrane roll number used and

subgrade acceptance for each panel deployed.

3) Seam Testing Log: provides a complete record of all nondestructive and destructive seam tests performed as part of the Geomembrane Installer's QC program.

4) Seam/Panel Repair Log: provides a complete record of all repairs and vacuum box testing of repairs made to defective seams or panels.

5) As-built Drawing: maintain an as-built drawing updated on a weekly basis.

b. CQC Consultant's Documentation

1) Daily Log: daily record that summarizes panels deployed, seams completed, CQC seam testing, seam repair, personnel on site, equipment on site, weather conditions, etc.

2) CQC Testing Log: record of all seam destructive tests and material conformance tests performed by the CQC Geosynthetics Laboratory.

3) Material Conformance: maintain original conformance certificate(s) from geomembrane manufacturer.

4) Subgrade Acceptance Log: maintained originals of subgrade acceptance forms for each panel and signed by the Geomembrane Installer.

3.02 GEOMEMBRANE ACCEPTANCE

A. The Geomembrane Installer shall retain all Ownership and responsibility for the geomembrane liner system until final acceptance by the Owner. Owner will accept the geosynthetic installation when the installation is finished and all required submittals from the Geomembrane Installer and CQC Consultant have been received and approved, and CQA verification of the adequacy of all field seams and repairs, including associated testing, is complete.

END OF SECTION

SECTION 02800

GEOSYNTHETIC CLAY LINER (GCL)

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Furnish all labor, material, and equipment to complete installation of the GCL in accordance with the Contract Drawings and these Specifications.
   2. Completely coordinate work with that of other trades.
   3. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.
   4. Furnish CQC Consultant to monitor the work of GCL Installer and to perform CQC testing in accordance with provisions of the Contract Documents.

B. Related Sections include but are not necessarily limited to:
   1. Section 02220 - Earthwork.
   2. Section 02775 - HDPE Geomembrane Liner.

1.02 QUALITY STANDARDS

A. Referenced Standards:
   1. American Society for Testing and Materials (ASTM).
      a. ASTM D 1777, Method for Measuring Thickness of Textile Materials.
      b. ASTM D 3776, Test Methods for Weight (mass) per Unit Area of Woven Fabric.
      c. ASTM D 4632, Test Method for Grab Breaking Load and Elongation of Geotextile.
      d. ASTM D 4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
      e. ASTM D 5084, Test Method for Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
      f. ASTM D 5321, Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

B. Qualifications:
   1. Manufacturer: The GCL shall be furnished by a Manufacturer that has previously produced a minimum of 1,000,000 square feet of the material for use in similar projects.

C. CQA Plan Implementation: Construction Quality Assurance documentation for the GCL installation will be performed for the

Owner by the CQA Consultant in accordance with the CQA Plan prepared for this project. The work performed under the CQA Plan is paid for by the Owner and is not a part of this contract. The Contractor, CQC Consultant, and GCL Installer, however, should familiarize themselves with the CQA Plan and are responsible for providing reasonable notice of and access to work elements that the CQA Consultant is required by the CQA Plan to overview.

1.03 SUBMITTALS

A. Pre-Installation: The Contractor shall submit the following information and material to the CQA Consultant prior to installation of the GCL.
   1. Product Data and Factory Test Results: Published product properties and specifications for the proposed GCL, as well as factory test results of materials certified by the GCL manufacturer shall be submitted showing conformance with the requirements of these Specifications. In addition, the Contractor shall submit the Manufacturer's certification stating that the material is similar to and of the same formulation as that for which test results are submitted, and by which actual usage has been demonstrated to be satisfactory for the intended application.
   2. Samples: Samples of the GCL sheeting shall be provided to the CQA Consultant. Samples shall have a width of 6 inches, and a length of 8 inches.
   3. Delivery, Storage, and Handling Instructions: The Manufacturer's recommendations for delivery, storage, and handling shall be submitted to the CQA Consultant for review.
   4. Delivery Date: The CQA Consultant shall be notified of the scheduled delivery date for the materials.
   5. Installation Drawings, Procedures, and Schedules: Installation drawings, procedures, and a schedule for carrying out the work shall be provided by the Contractor to the CQA Consultant for review. Procedures addressed by the Contractor shall include but not be limited to material unloading, storage, installation, repair, and protection to be provided in the event of rain. A schedule showing the order of placement, location of panels, seams, and penetrations shall be submitted for the CQA Consultant's review. Submit drawings showing the panel layout, seams, and associated details including pipe penetrations. Following review, these drawings will be used for installation of the GCL. Any deviations from these drawings must be approved by the CQA Consultant.

B. Post-Installation: Upon completion of GCL installation the Contractor shall submit the following to the CQA Consultant:
   1. A certificate stating that the GCL has been installed in accordance with the Plans, Specifications, and the Manufacturer's recommendations.
   2. Manufacturer's Warranty: The material warranty shall be for defects or failures related to manufacture on a non-prorata basis for five (5) years after date of shipment.

3. GCL Installer's Warranty: The GCL Installer's warranty shall warrant their workmanship to be free of defects on a non-prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to overlapped seams, anchor trenches, attachments to appurtenances, and penetration seals.
4. Record Drawing Information: Record drawings including but not limited to drawings showing the location of all seams, panels, repairs, patches, anchor trenches, pipe penetrations, and other appurtenances, including measurements and dimensions, shall be prepared by the Contractor and submitted to the CQA Consultant following completion of the project.

1.04 PROJECT CONDITIONS

A. The GCL shall not be placed in standing water, high humidity, or while raining. Any material that becomes partially or completely hydrated in the opinion of the CQA Consultant shall be removed and replaced at Contractor's expense.

B. Take necessary precautions to protect underlying soil and geomembrane liners from damage due to any construction activity. Damage to liners shall be repaired at Contractor expense.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General:
1. The GCL shall consist of bentonite encased, front and back, with geotextile. GCL consisting of bentonite backed with geomembrane can be used only if approved by the Project Manager and Engineer. The materials supplied under these Specifications shall be first quality products designed and manufactured specifically for the purposes of this work.
2. The GCL shall be supplied in rolls which have a minimum width of 12 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest overlaps. Labels on the roll shall identify the sheet number, date of fabrication, proper direction of unrolling, and minimum recommended overlap. A quality control certificate shall be supplied with each roll.
3. The GCL shall be reinforced where placed on slopes of 10H:1V or steeper. The GCL may be non-reinforced on slopes of less than 10H:1V.

B. Physical Properties: Physical properties of GCL shall be as shown in Table 1 of this section.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Shipping , Handling and Storage:
   1. During periods of shipment and storage, all GCL shall be protected from direct sunlight, water, mud, dirt, dust, and debris. To the extent possible, the GCL shall be maintained wrapped in heavy-duty protective covering until use. GCL delivered to the project site without protective wrapping shall be rejected.
   2. The Engineer shall approve the shipping and delivery schedule prior to shipment. The Engineer shall approve the on-site storage area for the GCL. Unloading and storage of GCL shall be the responsibility of the Contractor.
   3. GCL that is damaged during or storage shall be rejected and replaced at Contractor expense.

B. Installation of GCL:
   1. GCL shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, GCL shall be rejected by the CQA Consultant if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.
   2. The surface receiving the GCL shall be prepared to a relatively smooth condition, free of obstructions, excessive depressions, debris, and very soft or loose pockets of soil. This surface shall be approved by the CQA Consultant prior to GCL placement.
   3. The GCL shall be placed smooth and free of excessive wrinkles.
   4. The GCL shall be installed on sideslopes with vertical seams only.
   5. When GCL is placed with upslope and downslope portions, the upslope portion shall be lapped such that it is the upper or exposed surface.
   6. The GCL shall not be placed in standing water or while raining. Any material that becomes partially/totally hydrated shall be removed and replaced.
   7. The GCL seams shall be laid with a minimum overlap equal to 6 inches or the Manufacturer's recommendation, whichever is greater.
   8. GCL shall be temporarily secured in a manner approved by the CQA Consultant prior to placement of overlying materials.
   9. Any GCL that is torn or punctured shall be repaired or replaced as directed by the CQA Consultant, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of GCL placed over the failed areas and shall overlap the existing GCL a minimum of 12-inches from any point of the rupture.
   10. If in-place GCL is not otherwise protected from hydration due to rainfall, the GCL shall be covered with a minimum of 6 inches of the overlying design material within 24 hours of GCL placement.

3.02 FIELD QUALITY CONTROL

A. The CQA Consultant shall monitor and document the installation of GCL to ensure that the installation and necessary repairs are made

in accordance with these specifications.

3.03 GCL ACCEPTANCE

A. The GCL Installer shall retain all ownership and responsibility for the GCL until final acceptance by the Owner. The Owner will accept the GCL installation when the installation is finished, all required submittals have been received and approved, and CQC/CQA verification of the adequacy of all field seams and repairs, including associated testing, is complete.

TABLE 1: REQUIRED GCL PROPERTIES

GCL PROPERTY	TEST METHOD	VALUE	
		REINFORCED	NON-REINFORCED
Maximum Hydraulic Conductivity	ASTM D 5084 (@ 30 psi effective stress)	$5x10^{-9}$ cm/s	$5x10^{-9}$ cm/s
Minimum Bentonite Content	ASTM D 3776 (@ 20% moisture)	0.95 lb/sf	0.95 lb/sf
Minimum Grab Tensile Strength	ASTM D 4632	88 lbs	75 lbs
Minimum Puncture Resistance	ASTM D 4833	100 lbs	80 lbs
Minimum Shear Strength	ASTM D 5321	500 psf (When Hydrated)	50 psf
Minimum Free Swell	USP-NF-XVII	24 ml.	24 ml.
Maximum Moisture Content	ASTM D4643	30%	40%
Sodium Montmorillonite Content	X-Ray Diffraction	90 (Typ.)	90 (Typ.)

END OF SECTION

SECTION 02900

GEOTEXTILE FABRIC

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Geotextile fabric for all uses as shown in drawings including but not limited to:
      a. Cushion geotextile to protect geomembrane from #57 stone;
      b. Separator geotextile between LCR and operational cover;
      c. Protective geotextile when impregnated to limit flow into LCR; and
      d. Other - to suit field conditions

B. Related Sections include but are not necessarily limited to:
   1. Section 02220 - Earthwork.
   2. Section 02775 - Geosynthetic Liner System.
   3. CQA Plan.

1.02 QUALITY STANDARDS

A. Reference Standards:
   1. American Society for Testing and Materials (ASTM):
      a. D3776, Test Method for Mass Per Unit Area of Woven Fabric.
      b. D4354, Practice for Sampling of Geosynthetics for Testing.
      c. D4355, Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water.
      d. D4491, Test Method for Water Permeability of Geotextiles by Permittivity.
      e. D4632, Test Method for Grab Breaking Load and Elongation.
      f. D4751, Determining Apparent Opening Size of a Geotextile.
      g. D4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembrane, and Related Products.
      h. D4873, Guide for Identification, Storage, and Handling of Geotextiles.

B. Construction Quality Assurance Plan.

1.03 SUBMITTALS

A. Shop Drawings:
   1. See Section 01300.
   2. Product technical data.
   3. Manufacturer's delivery, storage, handling, and installation instructions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Geotextiles:
      a. Hoechst Celanese Corp.
      b. Advanced Drainage Systems Inc.
      c. Amoco Fabrics and Fibers Co.
      d. Or approved equal.

2.02 FABRICATION

A. Cushion Geotextile: Non-woven, needle punched; polyester or polypropylene; continuous filament or staple fibers; conforming to the following properties:

Property or Test Method	Required Value
Unit Weight (ASTM D3776)	.16 osy (minimum)
Grab Tensile Strength (ASTM D4632)	300 lb (minimum)

B. Separator Geotextile: Non-woven, needle punched; polyester or polypropylene; continuous filament or staple fibers; conforming to the following properties:

Property or Test Method	Required Value
Unit Weight (ASTM D3776)	.6 osy (minimum)
Grab Tensile Strength (ASTM D4632)	180 lb (minimum)
Elongation (ASTM D4632)	.50% (minimum)
Puncture Strength (ASTM D4833)	70 lb (minimum)
Apparent Opening Size (ASTM D4751)	.#50 US Sieve (minimum)
Permittivity (ASTM D4491)	0.5 sec-1 (minimum)

Alternative Separator Geotextile: Woven; polyester or polypropylene; conforming to the following properties:

Grab Tensile Strength (ASTM D4632)	180 lb (minimum)
Elongation (ASTM D4632)	.50% (minimum)
Puncture Strength (ASTM D4833)	70 lb (minimum)
Apparent Opening Size (ASTM D4751)	.#50 US Sieve (minimum)
Permittivity (ASTM D4491)	0.5 sec-1 (minimum)

C. Protective Geotextile: Nonwoven; polyester or polypropylene; continuous filament or staple fibers; conforming to the following properties:

Property or Test Method	Required Value
Unit Weight (ASTM D3776)	.6 osy (minimum)
Grab Tensile Strength (ASTM D4632)	180 lb (minimum)
Elongation (ASTM D4632)	.50% (minimum)

Puncture Strength (ASTM D4833). . . . . 70 lb (minimum)
Ultraviolet Stability (ASTM D4355) . . . . . .70% (minimum)

Alternative Protective Geotextile: Woven; polyester or polypropylene; conforming to the following properties:

Grab Tensile Strength (ASTM D4632) . . . . . 180 lb (minimum)
Elongation (ASTM D4632) . . . . . .50% (minimum)
Puncture Strength (ASTM D4833). . . . . 70 lb (minimum)
Ultraviolet Stability (ASTM D4355) . . . . . .70% (minimum)

PART 3 - EXECUTION

3.01 INSTALLATION

A. General Handling and Layout
   1. General storage and handling of geotextiles must meet requirements of ASTM D-4873.
   2. Exercise care when installing to prevent damage to geotextile.
   3. Lay out geotextile smooth and free of wrinkles, but loose enough that placement of overlying materials will not stretch or tear the fabric.
   4. Repair or replace geotextile that is torn or punctured. Repair by placing a geotextile patch over the damaged area, overlapping the existing geotextile by 12 IN (minimum) from any part of the damaged area. Repair or replace at no extra cost to Owner.
   5. Overlap rolls or sheets of geotextile 3 FT, minimum in the longitudinal direction.
   6. No equipment may operate directly on geotextiles. A minimum vertical separation of 9 IN must be maintained between all geotextiles and equipment tracks or wheels.

B. Seaming and Joining
   1. Cushion: Join sheets without sewing but with a minimum of 4 IN longitudinal overlap.
   2. Separator: Join sheets with or without sewing or heat bonding.
      a. With Sewing: Overlap adjacent panels a minimum of 4 IN. Use Type SSa (prayer) seam and a Type 401 stitch having a minimum distance from the edge of the geotextile to the stitch line of 2.0 IN or follow recommendations of geotextile manufacturer.
      b. With Heat Bonding: Overlap adjacent panels a minimum of 4 IN. Heat bond seam must develop a minimum of 60% of the tensile strength of the parent geotextile as measured in ASTM D4632.
      c. Without Sewing or Heat Bonding (Nonwoven only): Overlap adjacent rolls or sheets a minimum of 18 IN.
   3. Protective: Join sheets with sewing or heat bonding.
      a. With Sewing: Overlap a minimum of 4 IN. Use Type SSa (prayer) seam and a Type 401 stitch having a minimum distance from the edge of the geotextile to the stitch line of 2.0 IN or follow recommendations of geotextile manufacturer.

b. With Heat Bonding: Overlap adjacent panels a minimum of 4 IN. Heat bond seam must develop a minimum of 60% of the tensile strength of the parent geotextile as measured in ASTM D4632.

C. Cushion Geotextile
1. Place geotextile directly on the geomembrane.
2. Prevent movement of LCR pipe and GT-C geotextile while placing stone.

D. Separator Geotextile
1. Place fabric directly on a relatively smooth subgrade, free of obstructions, abrupt depressions or humps, debris, or deposits of loose or soft soil.
2. Care must be taken to avoid damaging the Type GT-S geotextile during placement of the soil over the geotextile. This may require use of a thicker loose lift or a smooth drum roller to limit damage due to penetration of compactor feet.

E. Protective Geotextile
1. Place geotextile directly on #57 stone.
2. Place operational cover on either side of stone drain.
3. The Protective geotextile is tack coated after placement to limit future surface water infiltration.
   a. A cationic or anionic water based asphalt emulsion may be used as approved by the Engineer.
   b. Minimum air temperature shall be at least $50^{o}F$ and rising for placement of the tack coat.
   c. The temperature of the tack coat shall be sufficiently high to permit a uniform spray pattern. To avoid damage to the geotextile, the maximum temperature shall not exceed $325^{o}F$.
   d. The application rate shall not be less than 0.20 gallons per square yard.

3.02 CQC TESTING

A. The CQC Consultant shall confirm that the identification, storage, and handling of geotextiles is in accordance with ASTM D4873. Any deviation from this requirement will be reported to the Engineer.

B. The CQC Consultant will examine all manufacturer's certifications to ensure that the property values listed on the certifications meet or exceed these specifications. Any deviations will be reported to the Engineer.

C. Conformance Testing: The CQC Consultant shall sample the geotextiles in accordance with ASTM D4354. Sample will be sent to the CQC Geosynthetics Laboratory for the following conformance testing. Any deviations will be reported to the Engineer.

1. Cushion Geotextile
   Unit Weight (ASTM D3776)
   Grab Tensile Strength (ASTM D4632)
2. Separator Geotextile

Unit Weight (ASTM D3776)
Grab Tensile Strength (ASTM D4632)
Elongation (ASTM D4632)
Puncture Strength (ASTM D4833)
Apparent Opening Size (ASTM D4751)
Permittivity (ASTM D4491)

3. Protective Geotextile
   Unit Weight (ASTM D3776)
   Grab Tensile Strength (ASTM D4632)
   Elongation (ASTM D4632)
   Puncture Strength (ASTM D4833)

D. The CQC Consultant will observe placement of the geotextiles to confirm that the panel overlaps and seams are in accordance with these specifications. Any deviations will be reported to the Engineer.

END OF SECTION

SECTION 02999

GEOCOMPOSITE DRAINAGE LAYER

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Geocomposite drain for all uses as shown in drawings including but not limited to:
      a. Overlying textured geomembrane liner to form the leachate collection system on the side slopes of the liner.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 02220 - Earthwork.
   4. Section 02775 - HDPE Geomembrane Liner.
   5. Section 02900 - Geotextile Fabric.
   6. CQA Plan.

1.02 QUALITY STANDARDS

A. Reference Standards:
   1. American Society for Testing and Materials (ASTM):
      a. ASTM D1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique.
      b. ASTM D792, Standard Test Methods for Density and Specific Gravity of Plastic by Displacement.
      c. ASTM D4716, Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextiles Related Products.
      d. ASTM D1777, Standard Method for Measuring Thickness of Textile Materials.

1.03 SUBMITTALS

A. Shop Drawings:
   1. See Section 01300.
   2. Product technical data.
   3. Manufacturer's delivery, storage, handling, and installation instructions.

PART 2 - PRODUCTS

2.01 FABRICATION

A. The geocomposite drainage layer shall be formed by thermally bonding a nonwoven geotextile to both faces of a geonet. Heat boding shall

be performed by the Manufacturer prior to shipping to the site.

B. The geonet shall be manufactured by extruding multiple sets of polyethylene strands to form a three-dimension structure to provide planer water flow.

C. Both geotextiles shall be 6 oz/sq.yd. nonwoven that meet the GT-S requirements of Section 02900 of these Specifications.

D. The geonet shall be manufactured by extruding two sets of polyethylene strands to form a three-dimensional structure that provides for planer flow.

E. The geonet shall have the following minimum properties:

Property	Test Method	Minimum Value
Thickness	ASTM D1777	0.200 inch
Resin Density	ASTM D1501	0.92 g/cc
Transmissivity	ASTM D4716	2.0 gal/min./ft*

* Conduct transmissivity test at a normal compressive load of 10,000 psf and a hydraulic gradient of 0.3. Boundary conditions are soil interface on the upper geotextile and HDPE geomembrane against the lower geotextile. Allow a seating period of 24 hours.

F. Each roll of geocomposite drainage media shall have the following identification information attached:
1. Manufacturer's name.
2. Product identification.
3. Thickness (geonet only).
4. Roll number.
5. Lot number.
6. Roll dimensions.

G. The manufactured rolls of geocomposite drain shall be wrapped or otherwise protected against moisture, dust, and dirt during shipping and storage. Geocomposite drainage media damaged during shipping or storage shall be replaced at Contractor's expense.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install geocomposite drain in accordance with manufacturer's written recommendations.

B. Geocomposite drainage media shall be placed to the lines and grades shown on the contract drawings.

C. The geocomponent drainage media shall be placed only on geomembrane that has been approved by the Geomembrane Installer and accepted by the CQC Consultant.

D. The Contractor shall provide temporary anchorage of the geocomposite drainage media at the top of berms during installation to prevent movement during construction. Permanent bonding to the geomembrane is prohibited.

E. Adjacent rolls of geonet shall be overlapped at a distance of at least 3 IN and secured using polyethylene ties placed every 5 FT.

F. Any geocomposite drainage media that is torn, crushed, or punctured shall be repaired or replaced by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same geocomposite drainage media placed over the damaged are and overlapped a minimum of 12 IN from any point of damage. The patch shall be attached to the geonet using polyethylene ties placed at least every 5 FT.

G. All soils placed over the composite drainage manner shall be placed in such a manner as to ensure:
   1. The geocomposite drainage media and the underlying geomembranes are not damaged in anyway.
   2. Minimal slippage of the geocomposite drainage media on the underlying geomembrane occurs; and
   3. No excess tensile stresses occur in the geocomposite drainage media.

2.02 QUALITY CONTROL

A. Prior to installation to the geocomposite drainage media, the CQC Consultant shall provide quality control certificates signed by the Manufacturer's quality assurance manager for every 50,000 ft2 of geocomposite drainage media to be installed.

B. The Contractor shall submit to the CQC Consultant for approval two full sets of field erection drawings showing panel layout for the geocomposite drainage media. The erection drawings shall show panel lengths, locations, overlaps, method of securing joints, jointing to penetrations as shown on the contract drawings.

END OF SECTION

SECTION 03002

CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Cast-in-place concrete and grout.
   2. Concrete mixes, proportioning, and source quality control for precast concrete.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 03431 - Precast Concrete.

1.02 QUALITY STANDARDS

A. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. SP-19, Cement and Concrete Terminology.
      b. 211.1, Standard Practice for Selecting Proportions for Normal and Heavyweight Concrete.
      c. 212.1R, Admixtures for Concrete.
      d. 212.2R, Guide for Use of Admixtures in Concrete.
      e. 214, Recommended Practice for Evaluation of Compression Test Results of Field Concrete.
      f. 304, Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.
      g. 305R, Hot Weather Concreting.
      h. 306R, Cold Weather Concreting.
      i. 318, Building Code Requirements for Reinforced Concrete.
      j. 347, Recommended Practice for Concrete Formwork.
   2. American Society for Testing and Materials (ASTM):
      a. A82, Standard Specifications for Cold Drawn Steel Wire for Concrete Reinforcement.
      b. A185, Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement.
      c. A615, Standard Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement Including Supplementary Requirements S1.
      d. C31, Standard Method of Making and Curing Concrete Test Specimens in the Field.
      e. C33, Standard Specification for Concrete Aggregates.
      f. C39, Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens.
      g. C94, Standard Specification for Ready Mixed Concrete.
      h. C138, Standard Method of Test for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.
      i. C143, Standard Method of Test for Slump of Portland Cement

Concrete.

j. C150, Standard Specification for Portland Cement.

k. C157, Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete.

l. C171, Standard Specification for Sheet Materials for Curing Concrete.

m. C172, Standard Method of Sampling Fresh Concrete.

n. C173, Standard Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method.

o. C192, Standard Method of Making and Curing Concrete Test Specimens in the Laboratory.

p. C231, Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method.

q. C260, Standard Specification for Air Entraining Admixtures for Concrete.

r. C289, Test Method for Potential Reactivity of Aggregates (Chemical Method).

s. C309, Standard Specification for Liquid Membrane Forming Compounds for Curing Concrete.

t. C494, Standard Specification for Chemical Admixtures for Concrete.

v. C496, Standard Method of Test for Splitting Tensile Strength of Cylindrical Concrete Specimens.

w. C595, Specification for Blended Hydraulic Cements.

x. C618, Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

y. E329, Standard Recommended Practice for Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction.

3. Federal Specification (FS):
   a. TT-S-227b, Sealer Compound; Rubber Base, Two Component.
   b. LLL-B-810B, Building Board, (Hardboard) Hard Pressed, Vegetable Fiber.

4. Corps of Engineers: Specification CRD-C572 Polyvinyl Waterstops.

B. Quality Control:

1. Concrete testing agency.
   a. Contractor to employ and pay for services of a testing laboratory to:
      1) Perform materials evaluation.
      2) Design concrete mixes.
   b. Concrete testing agency to meet requirements of ASTM E329.

2. Do not begin concrete production until proposed concrete mix design has been approved by Engineer.
   a. Approval of concrete mix design by Engineer does not relieve Contractor of his responsibility to provide concrete that meets the requirements of this Specification.

3. Adjust concrete mix designs when material characteristics, job conditions, weather, strength test results or other circumstances warrant.

a. Do not use revised concrete mixes until submitted to and approved by Engineer.

C. Qualifications: Ready mixed concrete batch plant certified by National Ready Mixed Concrete Association (NRMCA).

1.03 DEFINITIONS

A. Per ACI SP-19 except as modified herein:
1. Concrete fill: Non-structural concrete.
2. Concrete Testing Agency: Testing agency employed to perform materials evaluation, design of concrete mixes or testing of concrete placed during construction.
3. Exposed concrete: Exposed to view after construction is complete.
4. Indicated: Indicated by Contract Documents.
5. Lean concrete: Concrete with low cement content.
6. Nonexposed concrete: Not exposed to view after construction is complete.
7. Required: Required by Contract Documents.
8 Specified strength: Specified compressive strength at 28 days.
9. Submitted: Submitted to Engineer.

1.04 SUBMITTALS

A. Shop Drawings:
1. See Section 01300.
2. Concrete mix designs proposed for use. Concrete mix design submittal to include the following information:
a. Sieve analysis and source of fine and coarse aggregates.
b. Test for aggregate organic impurities.
c. Test for deleterious aggregate per ASTM C289.
d. Proportioning of all materials.
e. Type of cement with mill certificate for cement.
f. Type of fly ash with certificate of conformance to specification requirements.
g. Slump.
h. Air content.
i. Brand, type, ASTM designation, and quantity of each admixture proposed for use.
j. 28-day cylinder compressive test results of trial mixes per ACI 318 and as indicated herein.
k. Shrinkage test results.
l. Standard deviation value for concrete production facility.
3. Manufacturer and type of joint filler, joint sealant, curing agent and chemical floor hardener.
4. Manufacturer and type of bonding and patching mortar and bonding adhesive used at construction joints.
5. Manufacturer and type of nonshrink grout and the cure/seal compound required for the nonshrink grout.
6. Reinforcing steel: Show grade, sizes, number, configuration, spacing, location and all fabrication and placement details.

a. In sufficient detail to permit installation of reinforcing without having to make reference to Contract Drawings.
b. Obtain approval of shop drawings by Engineer before fabrication.
c. Mill certificates.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Delivery:
1. Concrete:
a. Prepare a delivery ticket for each load for ready-mixed concrete.
b. Truck operator shall hand ticket to Contractor at the time of delivery. All tickets should be available for review by Engineer.
c. Ticket to show:
1) Mix identification mark.
2) Quantity delivered.
3) Amount of each material in batch.
4) Outdoor temp in the shade.
5) Time at which cement was added.
6) Numerical sequence of the delivery.
7) Amount of water added.
2. Reinforcing steel: Ship to jobsite with attached plastic or metal tags with permanent mark numbers.
a. Mark numbers to match shop drawing mark number.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Nonshrink, nonmetallic grout:
a. Sika "SikaGrout 212."
b. Gifford Hill "Supreme Grout."
c. Master Builders "Masterflow 713."
d. Or equal.
2. Expansion joint fillers:
a. Permaglaze Co.
b. Rubatex Corp.
c. Williams Products, Inc.
d. Or equal.
3. Form coating:
a. Richmond "Rich Cote."
b. Industrial Lubricants "Nox-Crete Form Coating."
c. Protex "Pro-Cote."
d. Or equal.
4. Prefabricated forms:
a. Simplex "Industrial Steel Frame Forms."
b. Symons "Steel Ply."
c. Universal "Uniform."

d. Or equal.

2.02 MATERIALS

A. Portland Cement: Conform to ASTM C150 Type II

B. Fly Ash:
1. ASTM C618, Class F.
2. Nonstaining.
a. Hardened concrete containing fly ash to be uniform light gray color.
3. Maximum loss on ignition: 6 percent.
4. Compatible with other concrete ingredients.
5. Obtain proposed fly ash from a source approved by the State Highway Department in the state where the Project is located for use in concrete for bridges.
6. Do not use for precast concrete.

C. Admixtures:
1. Air entraining admixtures: ASTM C260.
2. Water reducing, retarding, and accelerating admixtures:
a. ASTM C494 Type A through E.
b. Conform to provisions of ACI 212.1R and ACI 212.2R.
c. Do not use retarding or accelerating admixtures unless specifically approved in writing by Engineer and at no cost to Owner.
d. Follow manufacturer's instructions.
e. Use chloride free admixtures only.
3. Maximum total water soluble chloride ion content contributed from all ingredients of concrete including water, aggregates, cementitious materials and admixtures by weight percent of cement:
a. 0.06 prestressed concrete.
b. 0.10 all other concrete.
4. Do not use calcium chloride.
5. Pozzolanic admixtures: ASTM C618.
6. Provide admixtures of same type, manufacturer and quantity as used in establishing required concrete proportions in the mix design.

D. Water: Potable, clean, free of oils, acids and organic matter.

E. Aggregates:
1. Normal weight concrete: ASTM C33, except as modified below.
2. Fine aggregate: Clean natural sand.
a. No manufactured or artificial sand.
3. Coarse aggregate: Crushed rock, natural gravel, or other inert granular material.
a. Maximum amount of clay or shale particles: 1 percent.
4. Gradation of coarse aggregate:
a. Lean concrete and concrete topping: Size #7.
b. All other concrete: Size #57 or #67.
5. Coarse aggregate for lightweight concrete: ASTM C330.

a. Maximum size: 3/4 IN.

F. Concrete Grout:
1. Nonshrink nonmetallic grout:
a. Nonmetallic, noncorrosive, nonstaining, premixed with only water to be added.
b. Grout to produce a positive but controlled expansion.
c. Mass expansion not to be created by gas liberation.
d. Minimum compressive strength of nonshrink grout at 28 days: 6500 psi.

G. Reinforcing Steel:
1. Reinforcing bars: ASTM A615, Grade 60.
a. Provide with epoxy coating per ASTM A775.
2. Welded wire fabric: ASTM A185.
a. Minimum yield strength: 60,000 psi.
3. Column spirals: ASTM A82.

H. Forms:
1. Prefabricated or job built.
2. Plywood: PS1, waterproof, resin bonded, exterior-type Douglas Fir.
a. Face adjacent to concrete Grade B or better.
3. Fiberboard: Fed Spec LLL-B-810, Type IX, tempered, waterproof, screen back, concrete form hardboard.
4. Lumber: Straight; uniform width and thickness; and free from knots, offsets, holes, dents, and other surface defects.
5. Chamfer strips: Clear white pine, surface against concrete planed.
6. Form ties: Removable end, permanently embedded body type with cones on outer ends not requiring auxiliary spreaders.
a. Cone diameter: 3/4 IN minimum to 1 IN maximum.
b. Embedded portion 1 IN minimum back from concrete face.
c. If not provided with threaded ends, constructed for breaking off ends without damage to concrete.
7. Form release: Nonstaining and shall not prevent bonding of future finishes to concrete surface.
a. Nontoxic 30 days after application.

I. Chairs, Runners, Bolsters, Spacers, and Hangers:
1. Stainless steel, epoxy coated, or plastic coated metal.
a. Plastic coated: Rebar support tips in contact with the forms only.

J. Expansion Joint Filler:
1. Asphalt impregnated fiber type.

2.03 CONCRETE MIXES

A. General:
1. All concrete to be ready mixed concrete conforming to ASTM C94.
2. Provide concrete of specified quality capable of being placed

without segregation and, when cured, of developing all properties required.

3. All concrete to be normal weight concrete.

B. Strength:

1. Provide specified strength and type of concrete for each use in structure(s) as follows:

TYPE	WEIGHT	SPECIFIED STRENGTH*
Precast Concrete	Normal weight	5000 psi
All other Concrete	Normal weight	4000 psi

*Minimum 28-day compressive strength.

C. Air Entrainment: Provide air entrainment in all concrete resulting in a total air content percent by volume as follows:

MAX AGGREGATE SIZE	TOTAL AIR CONTENT PERCENT
1 IN or 3/4 IN	5 to 7
1/2 IN	6 to 8

1. Air content to be measured in accordance with ASTM C231, ASTM C173, or ASTM C138.

D. Slump: 4 IN maximum, 1 IN minimum.

1. Measured at point of discharge of the concrete into the concrete construction member.
2. Pumped concrete: Provide concrete with appropriate mix design so that slump of concrete at discharge end of pump hose does not exceed maximum slump specified above.
3. Determine slump per ASTM C143.

E. Selection of Proportions:

1. General - Proportion ingredients to:
   a. Produce proper workability, durability, strength, and other required properties.
   b. Prevent segregation and collection of excessive free water on surface.
2. Minimum cement contents and maximum water cement ratios for concrete to be as follows:

	MINIMUM CEMENT, LB/CY			
SPECIFIED STRENGTH	MAXIMUM AGGREGATE SIZE, IN 1/2	3/4	1	MAXIMUM WATER CEMENT RATIO BY WEIGHT
3000	---	517	517	0.45
4000	611	611	611	0.45
5000	---	686	665	0.40

3. Substitution of fly ash:
   a. Maximum of 15 percent by weight of cement at rate of 1 LB fly ash for 1 LB of cement.
4. Submit mix design data as required by this specification section.
5. Normal weight concrete: Proportion mixture to provide desired characteristics using one of methods described below:
   a. Method 1 (Trial Mix): Per ACI 318, Chapter 5, except as modified herein.
      1) Air content within range specified above.
      2) Record and report temperature of trial mixes.
      3) Proportion trial mixes per ACI 211.1.
   b. Method 2 (Field Experience): Per ACI 318, Chapter 5, except as modified herein:
      1) Field test records must be acceptable to Engineer to use this method.
      2) Test records shall represent materials, proportions and conditions similar to those specified.
6. Required average strength to exceed the specified 28-day compressive strength by the amount determined or calculated in accordance with the requirements of paragraph 5.3 of ACI 318 using the standard deviation of the proposed concrete production facility as described in paragraph 5.3.1 of ACI 318.

PART 3 - EXECUTION

3.01 FORMING AND PLACING CONCRETE

A. General:
   1. Contractor is responsible for design and erection of formwork.
   2. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation and position.
      a. Allowable tolerances: As recommended in ACI 347.

B. Openings: Provide openings in formwork to accommodate work of other trades.
   1. Accurately place and securely support items built into forms.

C. Chamfer Strips: Place 3/4 IN chamfer strips in forms to produce 3/4 IN wide beveled edges on permanently exposed corners of members.

D. Reinforcement:
   1. Position, support and secure reinforcement against displacement.
   2. Locate and support with chairs, runners, bolsters, spacers and hangers, as required.
   3. Set wire ties so ends do not touch forms and are directed into concrete, not toward exposed concrete surfaces.
   4. Lap splice lengths: ACI 318 Class B top bar tension splices unless indicated otherwise on the Drawings.
   5. Extend reinforcement to within 2 IN of concrete perimeter

edges.
a. If perimeter edge is earth formed, extend reinforcement to within 3 IN of the edge.

6. Unless otherwise indicated, provide minimum concrete cover as follows:
a. Concrete deposited against earth: 3 IN.
b. Formed surfaces exposed to weather or in contact with earth: 2 IN for reinforcing bars #6 or larger; 1-1/2 IN for reinforcing bars less than #6.
c. Formed surfaces exposed to or located above any liquid: 2 IN.
d. Interior surfaces: 1-1/2 IN for beams, girders and columns; 3/4 IN or bar diameter, whichever is greater, for slabs, walls and joists.

7. Do not weld reinforcing bars.

8. Welded wire fabric:
a. Install welded wire fabric in maximum practical sizes.
b. Splice sides and ends with a splice lap length measured between outermost cross wires of each fabric sheet not less than:
1) One spacing of cross wires plus 2 IN.
2) 1.5 x development length.
3) 6 IN.
c. Development length: ACI 318 basic development length for the specified fabric yield strength.

E. Construction, Expansion, and Contraction Joints:
1. Provide at locations approved by the Engineer.
2. At least 48 HRS shall elapse between placing of adjoining concrete construction.
3. Thoroughly clean and remove all laitance and loose and foreign particles from construction joints.
4. Before new concrete is placed, coat all construction joints with an approved bonding adhesive used and applied in accordance with manufacturer's instructions.

F. Embedments:
1. Set and build in anchorage devices and other embedded items required for other work that is attached to, or supported by concrete.
2. Use setting diagrams, templates and instructions for locating and setting.

G. Preparation:
1. Clean and adjust forms prior to concrete placement.
2. Tighten forms to prevent mortar leakage.
3. Coat form surfaces with form release agents prior to placing reinforcing bars in forms.

H. Placing Concrete:
1. Place concrete in compliance with ACI 304 and 304.2R.
2. Place in a continuous operation within planned joints or sections.

3. Begin placement when work of other trades affecting concrete is completed.
4. Place concrete by methods which prevent aggregate segregation.
5. Do not allow concrete to free fall more than 4 FT.
6. Where free fall of concrete will exceed 4 FT, place concrete by means of tremie pipe or chute.

I. Consolidation:
1. Consolidate all concrete using mechanical vibrators supplemented with hand rodding and tamping, so that concrete is worked around reinforcement and embedded items into all parts of forms.

J. Protection:
1. Protect concrete from physical damage or reduced strength due to weather extremes.
2. In cold weather comply with ACI 306R except as modified herein.
   a. Do not place concrete on frozen ground or in contact with forms or reinforcing bars coated with frost, ice or snow.
   b. Minimum concrete temperature at the time of mixing:

OUTDOOR TEMPERATURE AT PLACEMENT (IN SHADE)	CONCRETE TEMPERATURE AT MIXING
Below 30 DegF	70 DegF
Between 30-45 DegF	60 DegF
Above 45 DegF	50 DegF

   c. Do not place heated concrete that is warmer than 80 DegF.
   d. If freezing temperatures are expected during curing, maintain the concrete temperature at or above 50 DegF for 7 days or 70 DegF for 3 days.
   e. Do not allow concrete to cool suddenly.
3. In hot weather comply with ACI 305R except as modified herein.
   a. At air temperature of 90 DegF and above, keep concrete as cool as possible during placement and curing.
   b. Do not allow concrete temperature to exceed 70 DegF at placement.
   c. Prevent plastic shrinkage cracking due to rapid evaporation of moisture.
   d. Do not place concrete when the actual or anticipated evaporation rate equals or exceeds 0.2 LBS/SF/HR as determined from ACI 305R, Figure 2.1.5.

K. Curing:
1. Begin curing concrete as soon as free water has disappeared from exposed surfaces.
2. Cure concrete by use of moisture retaining cover, burlap kept continuously wet or by membrane curing compound.
3. Provide protection as required to prevent damage to concrete and to prevent moisture loss from concrete during curing period.
4. Provide curing for minimum of 7 days.

5. Form materials left in place may be considered as curing materials for surfaces in contact with the form materials except in periods of hot weather.
6. In hot weather follow curing procedures outlined in ACI 305R.
7. In cold weather follow curing procedures outlined in ACI 306R.
8. If forms are removed before 7 days have elapsed, finish curing of formed surfaces by one of above methods for the remainder of the curing period.
9. Curing vertical surfaces with a curing compound: Cover vertical surfaces with a minimum of two coats of the curing compound.
   a. Allow the preceding coat to completely dry prior to applying the next coat.
   b. Apply the first coat of curing compound immediately after form removal.
   c. Vertical surface at the time of receiving the first coat shall be damp with no free water on the surface.
   d. A vertical surface is defined as any surface steeper than 1 vertical to 4 horizontal.

3.02 CONCRETE FINISHES

A. Tolerances:
   1. Class A: 1/8 IN in 10 FT.
   2. Class B: 1/4 IN in 10 FT.

B. Surfaces Exposed to View:
   1. Remove fins and projections, and patch voids, air pockets, and honeycomb areas with cement grout.
   2. Fill tie holes with nonshrink nonmetallic grout.

C. Surfaces Not Exposed to View:
   1. Patch voids, air pockets and honeycomb areas with cement grout.
   2. Fill tie holes with nonshrink nonmetallic grout.

D. Slab Float Finish:
   1. After concrete has been placed, consolidated, struck off, and leveled, do no further work until ready for floating.
   2. Begin floating when water sheen has disappeared and surface has stiffened sufficiently to permit operation.
   3. During or after first floating, check planeness of entire surface with a 10 FT straightedge applied at not less than two different angles.
   4. Cut down all high spots and fill all low spots during this procedure to produce a surface within Class B tolerance throughout.
   5. Refloat slab immediately to a uniform sandy texture.

E. Troweled Finish:
   1. Float finish surface.
   2. Next power trowel, and finally hand trowel.
   3. Produce a smooth surface which is relatively free of defects

with first hand troweling.

4. Perform additional trowelings by hand after surface has hardened sufficiently.
5. Final trowel when a ringing sound is produced as trowel is moved over surface.
6. Thoroughly consolidate surface by hand troweling.
7. Leave finished surface essentially free of trowel marks, uniform in texture and appearance and plane to a Class A tolerance.
8. On surfaces intended to support floor coverings remove any defects of sufficient magnitude that would show through floor covering by grinding.

F. Broom Finish: Immediately after concrete has received a float finish as specified, give it a transverse scored texture by drawing a broom across surface.

3.03 GROUT

A. Preparation:
   1. Nonshrinking nonmetallic grout:
      a. Clean concrete surface to receive grout.
      b. Saturate concrete with water for 24 HRS prior to grouting.

B. Application:
   1. Nonshrinking nonmetallic grout:
      a. Mix in a mechanical mixer.
      b. Use no more water than necessary to produce flowable grout.
      c. Place in accordance with manufacturer's instructions.
      d. Completely fill all spaces and cavities below the bottom of baseplates.
      e. Provide forms where baseplates and bedplates do not confine grout.
      f. Where exposed to view, finish grout edges smooth.
      g. Except where a slope is indicated on Drawings, finish edges flush at the baseplate, bedplate, member, or piece of equipment.
      h. Protect against rapid moisture loss by covering with wet rags or polyethylene sheets.
      i. Wet cure grout for 7 days, minimum.

3.04 FIELD QUALITY CONTROL

A. Contractor will employ and pay for services of a concrete testing laboratory to perform testing of concrete placed during construction.

B. Tests During Construction:
   1. Strength test - procedure:
      a. Four cylinders, 6 IN DIA x 12 IN high, will be taken from each sample per ASTM C172 and C31.
      b. Cylinders will be tested per ASTM C39:

1) One at 7 days.
2) Two at 28 days.
3) One spare for 56 day break if requested by Engineer.

2. Strength test - frequency:
   a. Not less than one test each day concrete placed.
   b. Not less than one test for each 50 CY or major fraction thereof placed in one day.
   c. Not less than one test for each type of concrete poured.
   d. Not less than one test for each concrete structure exceeding 2 CY volume.
3. Slump test: Per ASTM C143.
   a. Determined for each strength test sample.
   b. Additional slump tests may be taken.
4. Air content: Per ASTM C231, C173, and C138.
   a. Determined for each strength test sample.
5. Temperature: Determined for each strength test sample.
6. Unit weight of lightweight concrete.
   a. Determined for each strength test sample.
   b. Sample taken at point of discharge of fresh concrete.

C. Evaluation of Tests:
1. Strength test results: Average of 28-day strength of two cylinders from each sample.
   a. If one cylinder manifests evidence of improper sampling, molding, handling, curing or testings, strength of remaining cylinder will be test result.
   b. If both cylinders show any of above defects, test will be discarded.

D. Acceptance of Concrete:
1. Strength level of each type of concrete shall be considered satisfactory if both of the following requirements are met:
   a. Average of all sets of three consecutive strength tests equals or exceeds the required specified 28-day compressive strength.
   b. No individual strength test falls below the required specified 28-day compressive strength by more than 500 psi.

3.05 SCHEDULES

A. Form Types:
1. Surfaces exposed to view:
   a. Prefabricated plywood panel forms, job-built plywood forms, or forms lined with plywood or fiberboard.
   b. Laid out in a regular and uniform pattern with long dimensions vertical and joints aligned.
   c. Produce finished surfaces free from offsets, ridges, waves, and concave or convex areas.
   d. Construct forms sufficiently tight to prevent leakage of mortar.
2. Surfaces normally submerged or not normally exposed to view:
   a. Wood or steel forms sufficiently tight to prevent leakage of mortar.

3. Other types of forms may be used:
   a. For surfaces not restricted to plywood or lined forms.
   b. As backing for form lining.

B. Grout:
   1. Nonshrinking nonmetallic grout: General use.

C. Concrete:
   1. Precast concrete: Where indicated on Drawings.
   2. Normal weight concrete: All other locations.

D. Concrete Finishes:
   1. Grout cleaned finish: Where indicated on Drawings.
   2. Slab finishes:
      a. Use following finishes as applicable, unless otherwise indicated:
         1) Troweled finish: Base slabs of structures, and equipment bases.
         2) Broom finish: Sidewalks, docks, concrete stairs, and ramps.

END OF SECTION

SECTION 03431

PRECAST CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Precast concrete structures.

B. Related Sections include:
   1. Section 03002 - Concrete.

1.02 QUALITY STANDARDS

A. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. Standard Specifications for Highway Bridges.
   2. American Concrete Institute (ACI):
      a. 315, Manual of Standard Practice for Detailing Reinforced Concrete Structures.
      b. 318, Building Code Requirements for Reinforced Concrete.
   3. American Society for Testing and Materials (ASTM):
      a. A36, Standard Specification for Structural Steel.
      b. A108, Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality.
      c. A185, Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
      d. A496, Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
      e. C33, Standard Specification for Concrete Aggregates.
      f. C150, Standard Specification for Portland Cement.
      g. E329, Standard Recommended Practice for Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction.
   4. American Welding Society (AWS):
      a. A5.1, Standard Specification for Mild Steel Covered Arc-Welding Electrodes.
      b. A5.5, Standard Specification for Low-Alloy Steel Covered Arc-Welding Electrodes.
      c. D1.1, Structural Welding Code, Steel.
      d. D1.4, Structural Welding Code, Reinforcing Steel.
   5. Prestressed Concrete Institute (PCI):
      a. MNL-116, Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products.
      b. PCI Design Handbook Precast and Prestressed Concrete.

B. Qualifications:
   1. Provide units manufactured by plant which has regularly and continuously engaged in manufacture of units of same type as

those required for a minimum of 3 years.

2. Assure manufacturer's testing facilities meet requirements of ASTM E329.
3. Welding operators and processes to be qualified in accordance with:
   a. AWS D1.1 for welding steel shapes and plates.
   b. AWS D1.4 for welding reinforcing bars.
4. Welding operators to have passed qualification tests for type of welding required during the previous 12 months prior to commencement of welding.

1.03 DEFINITIONS

A. Installer or Applicator: Installer or applicator is the person actually installing or applying the product in the field at the Project site.

1.04 SUBMITTALS

A. Shop Drawings:
   1. See Section 01300.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
      c. Sizes, types and manufacturer of neoprene bearing pads.
      d. Hardware to be utilized to support suspended appurtenances.
   3. Shop drawings and erection plans for precast units, their connections and supports showing:
      a. Member size and location.
      b. Size, configuration, location and quantity of reinforcing bars.
      c. Size and location of openings verified by Contractor.
      d. Size, number, and locations of embedded metal items and connections.
      e. Required concrete strengths.
      f. Identification of each unit using same standard marking numbers as used to mark actual units.
   4. Concrete mix design(s) including submittal information defined in Sections 03002.
   5. Copies of source quality control tests.
   6. Certification of manufacturer's testing facility qualifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Transport and handle units with appropriate equipment to protect from dirt, chipping and damage.

B. Do not place units in positions which will cause overstress, warp or twist.

C. Utilize lifting inserts.

D. Store off ground.

E. Place stored units so that identification marks are visible.

F. Separate stacked members by wood battens across full width of each bearing point.

G. Stack so that lifting devices are accessible and undamaged.

H. Do not use upper member of stacked tier as storage area.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Concrete:
1. Minimum 28-day compressive strength of 5000 psi.
2 Provide concrete materials and proportions as required in Section 03002.
3. Concrete color to be gray.
4. Cement: Conform to ASTM C150 Type I or III.

B. Aggregates:
1. Crushed rock indigenous to area.
2. ASTM C33, Table 2, size number 67.
3. Aggregate quality per Section 03002.

C. Water:
1. Potable, clean.
2. Free of oils, acids, and organic matter.

D. Maximum total chloride ion content contributed from all ingredients of concrete including water, aggregates, cement and admixtures measured as a weight percent of cement to not exceed 0.06 for prestressed concrete and 0.10 for all other precast concrete.

E. Reinforcing Steel and Welded Wire Fabric: See Section 03002.

F. Electrodes:
1. E70 series conforming to AWS A5.1 or A5.5 for welding steel shapes and plates.
2. E90 series conforming to AWS A5.5 for welding rebar.

G. Metal Anchors, Inserts and Anchorages: Galvanized.

2.02 ACCESSORIES

A. Provide all connection items, lifting devices, anchors, and other

items secured to or embedded in units or other work as necessary to erect, support and anchor units.

B. Provide all accessories necessary for inter-locking units.

2.03 MIXES

A. See Sections 03002.

B. Do not begin fabrication of units until concrete mix design(s) have been approved by Engineer.

2.04 DESIGN

A. General Design Requirements:
1. Design units and connections in strict accordance with ACI 318 and the PCI Design Handbook Precast and Prestressed Concrete.
2. Design units for spans, dead load of members, dead and live loads indicated on the Drawings with concentrated loads placed in their actual locations. Verify weights and locations of concentrated loads.
3. Design units taking into account reduced cross section at openings and penetrations.
4. Provide all reinforcing in units as indicated. Where not indicated, design and provide all reinforcing subject to approval of Engineer.

2.05 FABRICATION

A. Do not fabricate units until shop drawings have been approved by Engineer and returned to Contractor and support locations have been field verified by Contractor.

B. Manufacture, quality, dimensional and erection tolerances of all units to be in accordance with both PCI MNL-116 and PCI Design Handbook Precast and Prestressed Concrete.

C. Cast all members in smooth rigid forms which will provide straight, true members of uniform thickness and uniform color and finish.

D. Use sand cement grout mixture to fill all air pockets and voids, and to repair chipped edges.

E. Finish all repairs smooth and to match adjacent surface texture and color.

F. Finish all horizontal surfaces subject to foot traffic with a broom finish.

G. Incorporate embedded plates, angles, lifting hardware, and flange welding strips into members at time of manufacture.

1. Provide manufacturer's standard flange welding strips provided such welding strips are approved by Engineer and are required by the Drawings.

H. Cast openings larger than 6 IN SQ or 6 IN DIA in units at time of manufacture. Make smaller openings by neat cutting or neat drilling by trades requiring them. Coordinate sizes and locations of all openings before fabrication of units.

I. Weld steel shapes and plates per AWS D1.1 and reinforcing steel per AWS D1.4.

J. Minimum concrete compressive strength at 28 days: All precast - 5000 psi.

K. Mark each unit as indicated on the erection plans. Place mark on non-exposed-to-view surface.

L. Curing: See Section 03002.

M. Design Criteria:
1. Provide engineering design performed by a registered professional Structural Engineer, licensed in the State and bearing their seal, as a part of this work.
2. Design and provide internal reinforcing and all embedded lifting device connections to withstand all erection forces.
3. Reinforce panels with reinforcing bars according to design criteria.

2.06 SOURCE QUALITY CONTROL

A. During production of precast concrete units, conduct strength tests of concrete placed in units as required in Specification Section 03002 for concrete placed during fabrication. Results of strength tests to be sent immediately to Engineer, Contractor and Owner. Test reports to indicate units they represent.

B. When approved by Engineer, strength tests may be made by precast manufacturer after he has submitted certification that his testing facilities meet the requirements of ASTM E329.

PART 3 - EXECUTION

3.01 PREPARATION

A. Verify acceptability and location of supports to receive units. Check bearing surfaces to determine that they are level and uniform.

B. Verify compressive strengths of concrete and masonry supports. Do not start erection of units until supports have reached their 28-day required compressive strengths.

3.02 ERECTION, INSTALLATION, APPLICATION

A. Contractor is responsible for all dewatering measures required for base soil preparation and for the correct bearing conditions needed for each precast structure.

B. Give consideration to possible lack of stability or capacity of partially completed frame or structure.

C. Contractor to be responsible for guying, shoring, and bracing of frame, walls and individual members as necessary to resist forces due to wind, erection, or any other source that may occur before a structure is completed.

D. Use only erection equipment adequate for placing units at lines and elevations indicated on Drawings. Do not damage units or existing construction during erection. Erect units using lifting handles or inserts cast into the units.

E. Weld steel shapes and plates per AWS D1.1 and reinforcing steel per AWS D1.4.

F. Patch defective concrete surfaces in accordance with method approved by Engineer.

3.03 FIELD QUALITY CONTROL

A. Causes for rejection of units include, but are not necessarily limited to the following:
   1. Cracked units.
   2. Chipped, broken, or spalled edges.
   3. Units not within allowable casting tolerances.
   4. Voids or air pockets which, in opinion of Engineer, are too numerous or too large.
   5. Non-uniform finish or appearance.
   6. Low concrete strength.
   7. Improperly placed embedded items and/or openings.
   8. Exposed wire mesh or reinforcing.

B. Do not stack sections concrete-to-concrete, but use wood separator strips or pads to prevent damage.

C. On initial delivery of all precast units, the Contractor shall inspect each, and accept or reject each, and shall call upon the Engineer for opinion if he deems it necessary to do so. A written record of acceptance or rejection of delivered precast parts shall always be entered into the daily construction log.

D. Replace any unit which exhibits damage to surfaces, finish, corners or edges which will be exposed to view after setting in place, or which is broken or cracked due to shrinkage, temperature, transportation, handling or erection, except, that when approved

in writing by Engineer unit may be repaired in place. Perform such work at no additional expense to Owner.

E. Acceptance of repaired unit, repaired pursuant to written approval, is contingent upon repairs being skillfully done so as to be sound, permanent, flush with adjacent surfaces and of color and texture matching similar adjoining surfaces and showing no apparent line of demarcation between original and repaired work. Remove and replace other work damaged by removal of defective panel members at no additional cost to Owner.

3.04 CLEANING

A. Leave units clean, free of traces of cleaning compound.

END OF SECTION

SECTION 15060

PIPE AND PIPE FITTINGS: GENERAL

PART 1 - GENERAL

1.01 DESCRIPTION

A. General:
1. Furnish all labor, materials, tools, equipment and services for all pipe and pipe fittings as indicated, in accordance with provisions of Contract Documents.
2. Completely coordinate with work of all other trades.
3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

B. Work required within the project consists of, but is not necessarily limited to the following piping systems:
1. Leachate collection and header piping systems (within lined areas).
2. Leachate gravity header piping (outside lined areas).
3. Culverts.

1.02 QUALITY STANDARDS

A. Related requirements:
1. Section 01300: Submittals
2. Section 02221: Trenching, Backfilling and Compacting
3. Section 03431: Precast Concrete
4. Section 15064: Pipe: Plastic

B. Refer to accompanying CQA/CQC Plan.

1.03 SUBMITTALS

A. See Section 01300.

B. Verify on shop drawings dimensions, schedule of pipe, fittings, hangers, supports and miscellaneous appurtenances. When special fittings are necessary, verify locations of items and include complete details.

C. As work progresses and again when work is complete, submit "As-Recorded" drawings of piping systems including project items and pre-existing items. Identify complete location, elevation, description of piping systems. Relate piping systems to identified structures and appurtenances.

D. Submit written verification of required quality control testing.

PART 2 - PRODUCTS

2.01 GENERAL PIPING SCHEDULE

A. Unless otherwise shown on drawings, piping system materials, fittings and appurtenances are subject to requirements of specific technical specifications and shall be as follows:

Service Category	Size Range	Piping System
Leachate Collection	all sizes	HDPE
Leachate Gravity Header Piping	all sizes	HDPE
Culverts	all sizes	RCP or CMP

PART 3 - EXECUTION

3.01 DELIVERY, INSPECTION AND STORAGE

A. Inspect materials thoroughly upon arrival. Remove damaged or rejected materials from site.

B. Observe manufacturer's directions for delivery and storage of materials and accessories.

C. Store materials on site in enclosures or under protective coverings above ground to keep clean and dry.

3.02 HANDLING OF PIPE

A. Protect pipe coating during handling using methods recommended by manufacturer. Use of bare cables, chains, hooks, metal bars or narrow skids in contact with coated pipe is not permitted.

B. Prevent damage to pipe during transit. Repair abrasions, scars, and blemishes. If repair of satisfactory quality cannot be achieved, replace damaged material immediately.

C. Install piping to accurate lines and grades and support as required on drawings or described in specifications. When temporary supports are used, insure that sufficient rigidity is provided to prevent shifting or distortion of pipe. Install expansion devises as necessary to allow expansion and contraction movements.

3.03 PIPING - GENERAL

A. Minimum bury. Unless otherwise shown on the drawings, provide a

minimum of three (3) FT earth cover over exterior buried piping systems and appurtenances conveying water, fluids, or solutions subject to freezing.

3.04 PIPING WITHIN BUILDINGS, STRUCTURES AND UNITS

A. Install piping in vertical and horizontal alignment as shown on drawings.

B. Use methods of piping support as shown on drawings.

C. Locate and size sleeves required for piping system. Arrange insert or anchors at proper elevation and location.

3.05 PIPING OUTSIDE STRUCTURES

A. Install piping as shown on drawings with ample clearance and allowance for expansion or contraction.

B. Install flexible joint within two (2) FT of point where pipe enters or leaves structure. Install second flexible joint not more than six (6) FT nor less than four (4) FT from first joint. Provide balance of piping with standard laying lengths and in accordance with drawings.

3.06 PIPE INTERSECTIONS WITH STRUCTURES AND UNITS

A. Enter and exit through structure walls by using wall seals specified or as shown on drawings.

3.07 EQUIPMENT PIPE CONNECTIONS

A. Exercise care in bolting flanged joints so that there is no restraint on the opposite end of pipe or fitting which would prevent uniform gasket pressure at connection or would cause unnecessary stresses to be transmitted to equipment flanges. Where push-on joints are used in conjunction with flanged joints, final positioning of push-on joints shall not be made until flange joints have been tightened without strain.

B. Tighten flange bolts at uniform rate which will result in uniform gasket compression over entire area of joint. Provide tightening torque in accordance with manufacturer's recommendations.

C. Support and match flange faces to uniform contact over their entire face area prior to installation of any bolt between the piping flange and equipment connecting flange.

D. Permit piping connecting to equipment to freely move in directions parallel to longitudinal centerline when and while bolts in connection flange are tightened. Align, level, and wedge equipment into place during fitting and alignment of connecting piping. Grout equipment into place prior to final

bolting of piping but not before initial fitting and alignment. To provide maximum flexibility and ease of alignment, assemble connecting piping with gaskets in place and minimum of four (4) bolts per joint installed and tightened. Test alignment by loosening flange bolts to see if there is any change relationship of piping flange with equipment connecting flange. Realign as necessary to performance of alignment test, install flange bolts and make equipment connection.

E. Provide utility connections to equipment shown on drawings, scheduled or specified.

F. Obtain rough-in data from approved shop drawings on equipment.

G. Unless otherwise specified, make piping connections to equipment, including but not limited to installation of fittings, flow control valves and relief valves provided with or as integral part of equipment.

H. Provide gaskets of rubber or Teflon impregnated asbestos for flanged pipe joints not otherwise specified.

3.08 BUTT FUSION PROCEDURES

A. All perforated leachate collection piping and solid wall cleanouts and gravity header piping shall be joined using manufacturer's recommended butt-fusion procedures.

3.09 LINING-UP PUSH-ON JOINT PIPING

A. Lay piping on route lines shown. Deflect from straight alignments or grades by vertical or horizontal curves or offsets. Maximum offset between extended centerlines of any two (2) adjacent pipe lengths is as follows:

Size of Pipe	Offset Allowance
All sizes	4/D

1. Where D is diameter of pipe in inches. Offset distance is expressed as inches per lineal foot of pipe.

B. Provide special bends when specified or where required alignment exceeds allowable deflections stipulated. Install shorter lengths of pipe in such length and number that angular deflection of any joint, as represented by specified maximum deflection, is not exceeded.

3.10 LAYING PIPE IN TRENCH

A. Excavate and backfill trench in accordance with Section 02221.

B. Clean each pipe length thoroughly and inspect for compliance to

specifications. Grade trench bottom and excavate for pipe bell (as applicable) and lay pipe on trench bottom. Install gasket or joint material (as applicable) according to manufacturer's directions after joints have been thoroughly cleaned, examined, and approved by the CQA Consultant.

C. Except for first two joints, before making final connections of joints, two (2) full sections of pipe shall have been previously installed with earth tamped along side of pipe or final bedding material placed.

D. Lay pipe in only suitable weather with good trench conditions. Never lay pipe in water except where approved by the Project Manager or CQA Consultant or where intended for water crossing.

3.11 EMBEDMENT REQUIREMENTS

A. Insure that piping is adequately supported. Provide pipe bedding incorporated in Section 02221 and in accordance with drawings.

3.12 ANCHORAGE AND BLOCKING

A. Block, anchor, or harness exposed piping subjected to internal pressure, in internal pressure, in which mechanical, push-on, flexible, or similar joints are installed, to prevent separation of joints.

B. Provide reaction blocking, anchors, joint harnesses, or other acceptable means for preventing movement of piping caused by internal pressure in buried piping tees, wye branches, plugs, or bends.

C. Place concrete blocking so that it extends from fitting into solid undisturbed earth wall. Concrete blocks shall not cover pipe joints. Provide bearing area of concrete in accordance with drawings. In event that adequate support cannot be achieved against undisturbed soil, install restrained piping joints.

D. Provide reaction blocking, anchorages, or other supports for fittings as shown on drawings for piping installed in fills, unstable ground, above grade, or exposed within structures.

3.13 CLEANING

A. General:
1. Clean interior of piping systems thoroughly before installing. Maintain pipe in clean condition during installation.
2. Before jointing pipe, thoroughly clean and wipe joint contact surfaces and they properly dress and make joint.
3. Immediately prior to pressure testing, clean and remove grease, metal cuttings, dirt, or other foreign materials which may have entered the system.
4. At completion of work and prior to final acceptance,

thoroughly clean work installed under these specifications. Clean equipment,fixtures, pipe, valves, and fittings of grease, metal cuttings, and sludge which may have accumulated by operation of system, from testing or from other causes.

3.14 TESTING AND INSPECTION

A. Perform testing and inspection prior to cleaning and final acceptance. Acknowledge satisfactory performance of tests and inspections in writing to the Project Manager or CQA Consultant prior to final acceptance.

B. Types of testing and inspection to be employed for the piping systems include:
   1. Hydrostatic pressure testing.
   2. Low pressure air test.

C. Test and inspect all pipes and joints in designated sections. Provide all necessary equipment and perform all work required in connection with the tests and inspections.

D. The Contractor shall bear the cost of all testing and inspecting, locating and remedying of leaks and any necessary retesting and re-examination.

E. Hydrostatic pressure testing.
   1. Provide temporary restraints for expansion joints for additional pressure load under test. Equipment in piping system with rated pressure lower than pipe test pressure, shall be isolated by valves or blind flanges.
   2. Test piping to hydrostatic test pressure scheduled on drawings or otherwise indicated in the CQA/CQC Plan.

F. Low pressure test.
   1. For gravity piping where low pressure testing is required or noted on schedules, comply with Testing Methods outlined in these paragraph specifications for test performance unless otherwise specified in the CQA/CQC Plan. Insure all gravity sewers comply with Infiltration - Exfiltration Testing criteria after backfill and compaction are satisfied.
   2. Infiltration. Perform and observe following testing criteria and procedures. Maximum infiltration allowance is 100 gpd/IN diameter/mile.
      a. Infiltration test procedure:
         1) Plug upper section of line.
         2) Install suitable measuring device at lower end.
         3) Measure amount of water flowing through outlet over a specified period of time.
   3. Exfiltration. Perform and observe following testing criteria and procedures. Maximum exfiltration allowance is 100 gpd/IN diameter/mile.
      a. Exfiltration air test procedure:
         1) Check pneumatic plugs for proper sealing.

2) Place plugs in line at each manhole and inflate to 25 psig.
3) Introduce low pressure air into sealed line until air pressure reaches 4 psig greater than average back pressure of any ground water that may be over the pipe. Use test gage conforming to ANSI B40.1 with 0 to 15 psi scale and an accuracy of 1 percent of full range.
4) Allow two (2) minutes for air pressure to stabilize.
5) After stabilization period (3.5 psig minimum pressure in pipe) discontinue air supply to line segment.
6) Acceptable time for loss of one (1) psig of air pressure shall be:

Pipe Size (IN)	Time, Minutes/100 FT
6	0.7
8	1.2
10	1.5
12	1.8

G. Repair or replace defective joints, pieces of pipe, jointing materials, and related work and repeat pressure testing until piping in each system meets the test criteria. Additional costs to be paid by the Contractor. Caulking of screwed joints or holes will not be acceptable.

3.15 LOCATION OF BURIED OBSTACLES

A. Furnish exact location of buried utilities encountered and any below grade structures. Reference items to definitive reference point locations such as found property corners, existing structure lines and related fixed structures. Include such information as location, elevation, coverage, supports and additional pertinent information which will be required by future contractors for replacement servicing, or adjacent construction around any buried facility.

B. Incorporate information to "As-Recorded" drawings.

3.15 SPECIAL REQUIREMENTS AND PIPING SPECIALTIES

A. Heat tracing.
1. Provide electric heat tracing on pipe systems for freeze protection to locations shown on the drawings. Ensure heat tape is self-limiting, parallel circuit construction consisting of an inner core of conductive material between parallel copper bus wires, with inverse temperature-conductivity characteristics. Provide heat tracing as manufactured by Chemelex or equal.
2. Provide all necessary components such as end seals, straps, tape and fitting brackets.

3. Provide components and installations approved for Class I, Division I explosion proof service (as applicable).
4. Install each system in strict accordance with manufacturer's instructions and recommendations.
5. Provide and connect thermostats.

END OF SECTION

SECTION 15064

PIPE: PLASTIC

PART 1 - GENERAL

1.01 DESCRIPTION

A. General:

1. Work items in project include, but are not necessarily limited to the following:
   a. HDPE Leachate Collection and Header Piping.
   b. HDPE Gravity Header Piping.
   c. HDPE Force Main Piping.
   d. HDPE Cleanout Risers.
2. Furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of plastic pipe, as shown on drawings and specified in accordance with provisions of the Contract Documents.
3. Completely coordinate work with that of all other trades.
4. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.

1.02 QUALITY STANDARDS

A. Refer to the following standards and include as part of these specifications:

1. PVC Materials:

ASTM D1785	Schedule 40, 80 and 120 PVC Plastic Pipe
ASTM D2412	External Loading Properties of Plastic Pipe by Parallel - Plate Loading
ASTM D2564	Solvent Cements for (PVC) Plastic Pipe, Tubing and Fittings
ASTM D2729	(PVC) Sewer Pipe and Fittings
ASTM D3034	Type PSM - PVC Sewer Pipe and Fittings
ASTM D3212	Joints

2. (HD) Polyethylene Materials:
   1) D-1505, Density
   2) D-1238, Melt Index
   3) D-790, Flexural Modulus
   4) D-638, Tensile Strength
   5) D-1693, Environmental Stress Crack
   6) D-2513, D-3261, D-2683, Molded Fittings

7) D-3350, Materials
8) F-714, Dimensions and Workmanship

C. CQA/CQC Plan (Attached to Technical Specifications).

1.03 SUBMITTALS

A. See Section 01300.

B. Verify on shop drawings dimensions, schedule of pipe, fittings, and miscellaneous appurtenances. When special fittings are necessary, verify locations of items and include complete details.

C. Render copies of any manufacturer's written instructions regarding material handling, delivery, storage, and installation.

D. As work progresses and again when work is complete, submit "As Recorded" drawings of piping systems in project including project items and pre-existing items. Identify complete location, elevation, and description of piping systems. Relate piping systems to identified structures and appurtenances.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Polyvinyl Chloride Piping (PVC)
1. Materials. Furnish materials in full compliance to the following material specification: PVC pipe shall be rigid, unplasticized polyvinyl chloride (PVC) made of PVC plastic having a cell classification of 12454-B or 12454-C as described in specification ASTM D1784.
2. Provide Schedule 80 pipe and fittings meeting or exceeding all requirements of ASTM D1785 and ASTM 2467. All joints to be socket-type.
3. Solvent cement weld joints in accordance with ASTM D2564.

B. HDPE LEACHATE PIPING (HDPE)
1. General: Provide pipe and appurtenances including perforations as shown on the Drawings.
2. Pipe: High density, high molecular weight polyethylene piping having a classification of PE 345434C.
3. Installation: All joints shall be butt fusion welds as recommended by the manufacturer and approved by the Project Manager.
4. Pipe type and sizing per drawings.

PART 3 - EXECUTION

3.01 DELIVERY AND STORAGE

A. Inspect materials thoroughly upon arrival. Examine materials for damage. Remove damaged or rejected materials from site.

B. Observe manufacturer's instructions for delivery and storage of materials and accessories.

3.02 HANDLING OF PIPE

A. Protect pipe during handling using methods recommended by manufacturer.

B. Prevent damage to pipe during transit. Replace damaged material immediately.

C. Install piping to accurate lines and grades and support as required on drawings or described in specifications. When temporary supports are used, ensure that sufficient rigidity is provided to prevent shifting or distortion of pipe.

3.03 PIPE INSTALLATION

A. Piping Outside Structures:
1. Install piping as shown on drawings with ample clearance and allowance for expansion or contraction.

B. Pipe Intersections with Structures and Units:
1. Install piping as shown on drawings and enter and exit through structure walls in accordance with penetration requirements specified on the Plans.

C. Laying Pipe in Trench:
1. Excavate and backfill trench as shown on Drawings and Technical Specifications.
2. Clean each pipe length thoroughly and inspect for compliance to specifications. Grade trench bottom and excavate for pipe bell (as applicable) and lay pipe on trench bottom. Install gasket or joint material (as applicable) according to manufacturer's directions after joints have been thoroughly cleaned and examined.
3. Lay pipe only in suitable weather with good trench conditions. Never lay pipe in water except where approved by CQA Consultant or Project Manager or intended for water crossing.
4. The Contractor shall be responsible for protection of the synthetic liner during installation of the leachate collection system piping.
5. Install pipe and fittings in accordance with ASTM D2321 or as recommended by the manufacturer for the intended application. See Drawings for bedding and backfilling conditions.

D. Bedding Requirements:
1. Ensure that piping is adequately supported. Provide pipe

bedding in accordance with Drawings and Specification Section 02221.

3.04 CLEANING

A. General Cleaning:
1. Clean interior of piping systems thoroughly of foreign matter before installing. Maintain pipe in clean condition during installation.
2. Before jointing pipe, thoroughly clean and wipe joint contact surfaces and then properly dress and make joint.
3. Immediately prior to pressure testing of PVC piping systems, clean and remove grease, dirt or other foreign materials which may have entered the system.
4. Upon completion of work and prior to final acceptance, thoroughly clean work installed under these specifications. Clean pipe, valves and fittings of debris which may have accumulated by operation of system, from testing or from other causes.

3.05 TESTING AND INSPECTION

A. Perform testing and inspection prior to cleaning and final acceptance. Acknowledge satisfactory performance of tests and inspections in writing to CQA Consultant prior to final acceptance.

B. Types of testing and inspection to be employed for the piping systems include: Low Pressure Air Test unless otherwise approved by the Project Manager and CQA Consultant.

C. Test and inspect all pipes, fittings and joints. Provide all necessary equipment and perform all work required in connection with the tests and inspections.

D. Bear the cost of all testing and inspecting, locating and remedying of Leaks, and any necessary retesting and re-examination.

E. Refer to Section 15060, Paragraph 3.13-F for low pressure test requirements.

END OF SECTION

SECTION 15066

PIPE: STAINLESS STEEL

PART 1 - GENERAL

1.01 SUMMARY

A. General work included in this Section:
   1. Stainless steel piping, fittings and appurtenances, as required to protect the cleanout riser piping.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 15060 - Pipe and Pipe Fittings: General.

1.02 QUALITY STANDARDS

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. B16.5, Pipe Flanges and Flanged Fittings.
   2. American Society for Testing and Materials (ASTM):
      a. A182, Standard Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service.
      b. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
      c. A312, Seamless and Welded Austenitic Stainless Steel Pipe.
      d. A320, Standard Specification for Alloy Steel Bolting Materials for Low Temperature Service.
      e. A351, Steel Castings, Austenitic, for High Temperature Service.
      f. A530, Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.
      g. A774, As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
      h. A778, Welded Unannealed Austenitic Stainless Steel Tubular Products.
   3. American Water Works Association (AWWA).
      a. M11, Steel Pipe - A Guide for Design and Installation

1.03 SUBMITTALS

A. Shop Drawings consistent with Section 01300.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Tubing: ASTM A269.
   1. Filler material: Extra low carbon (ELC) with 0.03 percent maximum carbon.

B. Pipe:
   1. ASTM A778.
   2. ASTM A351.

C. Pipe Fittings:
   1. ASTM A774.
   2. ASTM A351

D. Nuts, Bolts and Washers:
   1. ASTM A320, Type 316.
   2. Two nuts provided for 1 IN DIA bolt applications and larger.

E. Gasket Material:
   1. Rubber or neoprene.
   2. Temperature rating of 250 DegF.

2.02 FABRICATION

A. All tube, piping, fitting product to be immersion pickled subsequent to manufacturing and fabrication operations and prior to shipping.
   1. Pickling solution of 6-10 percent nitric acid and 3-4 percent hydrofluoric acid.
   2. Temperature and exact concentrations to be such only a modest etch is produced but all oxidation and ferrous contamination is removed from metal surface.
   3. All pickling solution residues are to be neutralized after pickling.

B. Diameter tolerance and wall thickness tolerance are to conform to ASTM A530.

C. Joints.
   1. Shop welded circumferential buttweld joints.
   2. Van Stone joints using angle face rings with backing flanges.
   3. ANSI B16.1, Class 150

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to installation, inspect and verify condition of piping and appurtenances. Installation constitutes installer's acceptance of condition for satisfactory installation.

3.02 PREPARATION

A. Correct defects or conditions which may interfere with or prevent a satisfactory installation.

B. Ensure ends of pipe to be fitted with flanges have all protrusions ground flush.

3.03 INSTALLATION

A. Install stainless steel pipe as protective casing for 6" (Nom.) Dia. HDPE cleanout riser, as shown on the drawings.

B. Embed the steel pipe within the concrete collar as shown on the drawings.

C. Provide tamper resistant locking cap pipe end, as shown on the drawings.

3.04 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Section 15060.

3.05 CLEANING

A. Clean in accordance with Section 15060.

END OF SECTION

SECTION 15069

PIPE: REINFORCED CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. Work covered by this section includes supplying and installing RCP culverts and drop inlet RCPs as shown on the Plans.

B. Related Sections include but are not necessarily limited to:
1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 1 - General Requirements.
3. Section 02221 - Trenching, Backfilling, and Compacting.
4. Section 03002 - Concrete.
5. Section 03431 - Precast Concrete.
3. Section 15060 - Pipe and Pipe Fittings: General.

1.02 QUALITY STANDARDS

A. Referenced Standards:
1. Reinforced concrete pipe (RCP):
   a. American Society for Testing and Materials (ASTM):
      1) C76, Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
      2) C361, Reinforced Concrete Low-Head Pressure Pipe.
      3) C443, Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible, Watertight, Rubber Gaskets.
   b. American Water Works Association (AWWA):
      1) C302, Reinforced Concrete Pressure Pipe, Non-Cylinder Water and Other Liquids.

2. Installation and testing:
   a. American Water Works Association (AWWA):
      1) M9, Installation of Concrete Pipe.

B. Conduct testing methods to evaluate physical properties of pipe in full compliance with ASTM C497 "Determining Physical Properties of Concrete Pipe or Tile." Report full results test showing compliance with referenced standard.

C. Determine acceptability of RCP in all diameters and classes by appropriate ASTM plant tests, including such test to indicate specified design strengths have been met prior to shipment.
1. Conduct three-edged bearing test as specified in AASHTO T280, or by the testing of cores in accordance with AASHTO T24. Complete bearing test prior to shipment date of lot tested.
2. Conduct crushing test, as specified on cured concrete cylinders. Achieve specified 28-day design compressive strength prior to shipment date of lot tested.

D. Provide each pipe, fitting, special appurtenance with a plainly and permanently waterproofed, marked identification. Include but not necessarily limit markings to the following:
   1. Size and class of pipe, pressure rating in compliance with referenced standards.
   2. Date of manufacture.
   3. Manufacturer's trademark.
   4. Manufacturer's name.
   5. Full details on fittings and pipe schedule regarding angles of change, reduction.
   6. Special notations and tagging of special items in regard to line location.

1.03 SUBMITTALS

A. Shop Drawings:
   1. See Section 03431, Part 1.04,A.

B. Furnish full details of reinforcement, concrete, and joints for the straight pipe, specials, and connections.

C. Detail special fittings and appurtenances showing reinforcement, concrete, and special requirements.

1.04 DELIVERY, STORAGE AND HANDLING

A. See Section 03431, Part 1.05.

PART 2 - PRODUCTS

2.01 FABRICATION

A. Provide non-pressure service or gravity drainage piping meeting or exceeding ASTM C76, Class IV (unless otherwise approved by the Engineer) with varying lengths a minimum of 7 FT long.
   1. Each lot shall consist of a single diameter and strength designation manufactured by essentially the same process.
      a. RCP manufactured with lifting holes shall not be furnished for installation below established water table.
   2. Provide RCP for non-pressure service or gravity drainage with sealed joints using continuous rubber gaskets conforming to the requirements of ASTM (C443 or C361).
   3. Type of joint shall be spigot groove type joint with O-ring gasket (R/C) equivalent to United States Bureau of Reclamation Type R/4. Ensure that the rubber gasket will perform as the sole element to make the joint watertight. Joint material and gaskets shall conform to NCDOT Standard Specifications for Highway Construction.
   4. An alternate type of joint may be used if approved by the Engineer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Observe all recommendations in accordance with AWWA M9 for installation, delivery, and storage of pipe material.

3.02 CONNECTIONS WITH EXISTING WORK

A. All connections made shall be performed in the same manner as the connections of the existing pipes unless otherwise approved by the Engineer.

B. All existing pipe which has been damaged shall be replaced with the same pipe using the same installation method as the existing pipe unless otherwise approved by the Engineer.

END OF SECTION

SECTION 15103

BUTTERFLY VALVES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Butterfly valves as included in manholes and distribution box as shown on the plans.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 15060 - Pipe and Pipe Fittings: General.
   4. Section 15064 - Pipe: Plastic

1.02 QUALITY STANDARDS

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. B16.1, Pipe Flanges and Flanged Fittings.
   2. American Society for Testing and Materials (ASTM):
      a. D2241, Specification for PVC Pressure-Rated Pipe.
      b. D2464, Specification for Threaded PVC Plastic Pipe Fittings, Schedule 80.
      c. D2466, Specifications for PVC Pipe Fittings, Schedule 40.
   3. American Water Works Association (AWWA):
      a. C504, Rubber Seated Butterfly Valves.
   4. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):
      a. SP-67, Butterfly Valves.

1.03 SUBMITTALS

A. Shop Drawings:
   1. See Section 01300.
   2. For valves 8 IN and larger, furnish "Affidavit of Compliance" with Owner in accordance with AWWA C504.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. ASAHI.
   2. Chemtrol.
   3. George Fischer.

4. Or approved equal.

B. Submit requests for substitution in accordance with Specification Section 01630.

2.02 BUTTERFLY VALVES

A. Materials:
1. Valve bodies:
a. ASTM A126, Class B, or ASTM A536, Grade 65-45-12 ductile iron.
b. Wafer valves may be constructed of ASTM A48, Class 40 cast iron.
2. Valve shafts:
a. Stainless steel, 18-8, Type 403 or 316.
3. Valve discs:
a. Potable and nonpotable water:
1) ASTM A48, Class 40 cast iron.
2) ASTM A536, Grade 65-45-12 ductile iron.
3) ASTM A436, Type 1 alloy cast iron.
4) Bronze in accordance with AWWA C504.
b. Wastewater and similar applications:
1) ASTM A436, Type 1 alloy cast iron.
2) ASTM A536, Grade 65-45-12 ductile iron.
3) ASTM A436, Type 1 alloy cast iron.
4) Bronze in accordance with AWWA C504.
c. Air and similar applications: ASTM A48, Class 40 cast iron:
4. Valve seats and seals:
a. Potable and nonpotable water below 150 DegF:
1) Natural rubber.
b. Potable and nonpotable water and wastewater and air below 180 DegF:
1) Buna-N.
c. Heating water and air 180 to 250 DegF.
1) EPDM.

C. Design Requirements:
1. Seat type: Resilient. Comply with AWWA C504.
2. Exposed and submerged valves 3 through 20 IN.
a. Body type: Wafer or short body flange (laying length may vary from AWWA C504).
b. Working pressure: Rated for 150 psi (Class 150B per AWWA C504).
c. Equip wafer type with fully tapped anchor lugs drilled per ANSI B16.5.
3. Exposed and submerged valves 24 IN and larger:
a. Body type: Short body flange.
b. Working pressure: Rated for 150 psi (Class 150B per AWWA C504).
4. Direct buried valves:
a. All valves: Working pressure rated for 150 psi (Class 150B per AWWA C504).

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to the construction plans for additional information and coordination with the HDPE manhole fabrication.

B. Comply with the manufacturer's installation guidelines and appropriate application recommendations.

END OF SECTION

SECTION 15900

PIPE - CORRUGATED METAL

PART 1 - GENERAL

1.01 DESCRIPTION

A. This item shall consist of furnishing, fabricating, and installing corrugated steel pipe culvert or corrugated aluminum pipe culvert of the types, classes, sizes, gauges, and dimensions as shown on the plans, at such places as are designated on the plans and profiles, or by the Engineer, in accordance with these specifications and in conformity with the lines and grades given.

B. Piping locations include, but may not be limited to:
   1. CMP culverts, and
   2. CMP risers/conduits as principal spillways in sediment basins A and B.

PART 2 - MATERIALS

2.01 GENERAL

A. Corrugated Steel Culvert Pipe and Connections: This pipe and connections shall conform to the requirements of AASHTO M 36 and AASHTO M 218.

B. Corrugated Aluminum Culvert Pipe and Connections: This pipe and connections shall conform to the requirements of AASHTO M 196.

C. Equivalent Gauges for C.M.P.s:

Specified Alum. Gauge	Min. Allowable Steel Gauge	Specified Steel Gauge	Min. Allowable Aluminum Gauge
18	18	18	14
16	18	16	12
14	16	14	12
12	12	12	8
10	12	10	None
8	10	8	None

D. Perforations: The perforations shall be located and sized in accordance with the Plans.

E. Aluminum Pipe: This pipe shall not be used in direct contact with steel pipe or other metals. Where it is necessary to repair an aluminum with steel, a proper insulation of the 2 dissimilar metals will be affected by use of a rubber or neoprene sheeting,

special fabricated coupling, or concrete expansion block or other methods as approved by the Engineer.

F. Coupling Bands: Flexible pipe shall be firmly joined by coupling bands. These bands shall be not more than two nominal sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than 0.052 inches. Unless specified otherwise, the Contractor shall have the option of furnishing any one of the following types of coupling bands.

1. Corrugated bands furnished and installed such that the band corrugations match and conform to the corrugations of the pipe. The gap between the pipe being joined shall be in the center of the band and shall be no wider than one corrugation width. Bands for 12-inch thru 30-inch diameter pipe shall have a minimum width of 12 inches. Bands for pipe with diameters greater than 30 inches shall have a minimum width of 22 inches.
2. Deformed sheet bands (dimple bands) furnished and installed such that the projections match and are of the same depth as the pipe corrugations. These projections shall be formed in circumferential rows with one projection for each corrugation of the helical pipe. Bands for 12-inch diameter pipe shall have a minimum width of 12 inches and shall have one circumferential row of projections for each pipe end being joined. Bands for pipe with diameters greater than 12 inches shall have a minimum width of 24 inches and shall have two circumferential rows of projections for each pipe end being joined. These bands shall be furnished and installed with gasket to provide resistance to infiltration and leakage. The gap between the pipe being joined shall be in the center of the band and shall be no wider than two inches. All bolted connections on coupling bands shall be furnished with cutwashers placed between the nut and the angle bracket, or nuts with integral washers.

G. Asphaltic or bituminous coatings shall be applied in conformance with manufacturers' requirements and NCDOT Standard Specification, as applicable.

PART 3 - EXECUTION

3.01 GENERAL

A. Equipment: All equipment necessary and required for the proper construction of culverts shall be on the project, in first class working condition. The Contractor shall provide such mechanical tampers as required to obtain the compaction of the pipe bedding and backfill as specified.

B. Excavation: The Contractor shall perform all excavation to the depth shown on the plans. The bedding for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench. Bedding shall

be as shown on the plans.

C. Placing Pipe: The pipe shall be laid with the separate sections joined firmly together with coupling bands with outside laps of circumferential joints pointing upgrade, and with longitudinal laps on the sides. The pipe shall be laid carefully and true to lines and grades on a bed which is uniformly firm throughout its entire length. Any pipe which is not in true alignment, or which shows any undue settlement after laid or or is damaged, shall be taken up and relaid or replaced without extra compensation. Pipe shall not be laid on frozen ground.

D. Connections: Contractor shall follow manufacturer's recommendations in installing pipe connections.

E. Backfill: The trench shall be backfilled with material as specified in Section 02221.

END OF SECTION